TRANSACTIONS

OF THE

KANSAS ACADEMY OF SCIENCE

(Founded in 1868)

VOLUME 42

F. C. GATES, *Editor*
W. J. BAUMGARTNER, *Managing Editor*

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TABLE OF CONTENTS

OFFICIAL

CONSTITUTION AND BYLAWS

CONSTITUTION*

SECTION 1. This association shall be called the Kansas Academy of Science.

SEC. 2. The objects of this Academy shall be to increase and diffuse knowledge in various departments of science.

SEC. 3. The membership of this Academy shall consist of three classes: annual, life and honorary.

(1) Annual members may be elected at any time by the committee on membership, which shall consist of the secretary and other members appointed, annually, by the president. Annual members shall pay annual dues of one dollar, but the secretary and treasurer shall be exempt from the payment of dues during the years of their service.

(2) Any person who shall have paid thirty dollars in annual dues, or equivalent due to legal exemption, or in one sum, or in any combination, may be elected to life membership, free of assessment, upon recommendation by the membership committee and a majority vote of those attending the annual business meeting of the Academy.

(3) Honorary members may be elected because of special prominence in science by being nominated by at least two Academy members in good standing, the nomination being submitted in writing to the membership committee for approval and recommendation to the Academy at its annual meeting. A two-thirds vote of all members present at the annual business meeting shall constitute election. Honorary members pay no dues.

SEC. 4. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall consist of a president, the president-elect, a vice-president, a secretary and a treasurer, who shall perform the duties usually pertaining to their respective offices. The president, the secretary and the treasurer shall constitute the executive committee. The secretary shall be in charge of all the books, collections and material property belonging to the Academy.

SEC. 5. Unless otherwise directed by the Academy, the annual meeting shall be held at such time and place as the executive committee shall designate. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This constitution may be altered or amended at any annual meeting by a vote of three-fourths of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

SEC. 7. This Academy shall have an executive council, consisting of the president, the president-elect, the secretary, the treasurer, the retiring presidents, the editor, the managing editor, and three other members to be nominated by the nominating committee and elected as the other officers. This

*As modified by amendments.

council shall have general oversight of the Academy not otherwise given by this Constitution to officers or committees.

SEC. 8. This Academy shall have an editorial board consisting of an editor, a managing editor, and four associate editors. These members shall be elected in the same manner as other officers, but for a period of three years. Two members of the board shall be elected every year, except that in 1935 the editor and one associate shall be elected for three years, the managing editor and one associate for two years and two associates for one year each.

The editor, with the aid of the associate editors, shall have general supervision of all editorial work submitted for publication in the Transactions, and shall be responsible for the selecting, editing, revision and rejection of papers submitted for publication. The managing editor shall be responsible for the making of the plates and the printing and general distribution of the Transactions.

BYLAWS

I. At the beginning of each annual session there shall be held a brief business meeting for announcements and appointment of committees. For the main business meeting, held later in the session, the following order is suggested:

1. Reports of officers.
2. Reports of standing committees.
3. Unfinished business.
4. New business.
5. Reports of special committees.
6. Election of officers.
7. Election of life and honorary members.

II. The president shall deliver a public address at one of the general sessions of the meeting, at the expiration of his term of office.

III. No meeting shall be held without a notice of the same having been published in the papers of the state at least thirty days previous.

IV. No bill against the Academy shall be paid by the treasurer without an order signed by the president and secretary.

V. Names of members more than one year in arrears in dues shall be dropped from the membership list.

VI. The secretary shall have charge of the distribution, sale and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the executive committee.

VII. Ten percent of the active membership shall constitute a quorum for the transaction of business. Section meetings may not be scheduled or held at the time a business meeting is called by the president at a general session or announced on the program.

VIII. The time allotted to the presentation of a single paper shall not exceed fifteen minutes.

IX. No paper shall be entitled to a place on the program unless the manuscript, or an abstract of the same, shall have been previously delivered to the secretary.

X. Section programs may be arranged by the secretary with the advice of the section chairmen. The subdivision or combination of existing sections

shall be dependent upon the number of papers to be presented. Such changes shall be made by the secretary in accordance with the policies of the Academy and after receiving the advice of the chairmen of the sections concerned.

XI. Section chairmen for the ensuing year shall be elected annually at the close of the section meetings.

XII. Section programs shall be limited to Friday afternoon of the annual session, but may be continued Saturday afternoon if desired by the section chairman. Exemptions to this must receive the approval of the executive committee.

XIII. In selecting papers for publication in the Transactions of the Kansas Academy of Science, the editor or editorial board shall refuse papers by non-members and members who are in arrears.

MEMBERSHIP OF THE ACADEMY

April 10, 1939

ABBREVIATIONS: The following abbreviations for institutions have been used:

U. of K.: University of Kansas.
K. S. C.: Kansas State College of Agriculture and Applied Science.
K. S. T. C.: Kansas State Teachers College.
F. H. K. S. C.: Fort Hays Kansas State College.
H. S.: High School.
Jr. H. S.: Junior High School.
Jr. Col.: Junior College.

The year given indicates the time of election to membership.

HONORARY MEMBERS

Barber, Marshall A., Ph. D., 1904, Internat. Health Div., Rockefeller Found., 49 W. Forty-ninth street, New York, N. Y.
Cockerell, T. D. A., D. Sc., 1908, prof. zoölogy (emeritus), Univ. Colorado, Boulder, Colo.
Grimsley, G. P., Ph. D., 1896, geological eng., B. & O. R. R., 4405 Underwood Road (Guilford), Baltimore, Md.
McClung, C. E., Ph. D., 1903, dir. zoölogy lab., Univ. Pennsylvania, Philadelphia, Pa.
McCollum, E. V., Ph. D., Sc. D., 1902, prof. biochemistry, Johns Hopkins Univ., Baltimore, Md.
Riggs, Elmer S., M. A., 1896, assoc. curator paleontology, Field Mus. Nat. Hist., Chicago, Ill.
Wagner, George, M. A., 1897 (honorary member 1904), prof. zoölogy, 73 Biology Bldg., Univ. Wisconsin, Madison, Wis.

LIFE MEMBERS

Agrelius, Frank U. G., M. A., 1905, assoc. prof. biol., K. S. T. C., Emporia, Kan.
Allen, Herman Camp, Ph. D., 1904, prof. chemistry, U. of K., Lawrence, Kan.
Bartow, Edward, Ph. D., Sc. D., 1897, prof. and head Dept. Chem. and Chem. Eng., State Univ. Iowa, Iowa City, Iowa.
Baumgartner, William J., Ph. D., 1904, prof. zoölogy, U. of K., Lawrence, Kan.
Beede, Joshua W., Ph. D., 1894, 31 S. Urban St., Tulsa, Okla.
Berry, Sister M. Sebastion, A. B., 1911, Supt. Schools, St. Paul, Kan.
Bushnell, Leland D., Ph. D., 1908, prof. and head Bacteriology Dept., K. S. C., Manhattan, Kan.
Cady, Hamilton P., Ph. D., 1904, prof. chemistry, U. of K., Lawrence, Kan.
Cook, W. A., M. S., 1907, real estate business. Address unknown.
Dains, Frank Burnett, Ph. D., 1902, prof. chemistry, U. of K., Lawrence, Kan.
Dean, Geo. A., M. S., 1903; 1912, head Dept. of Entomology, K. S. C., Manhattan, Kan.
Deere, Emil O., M. S., 1905, dean and prof. biology, Bethany Col., Lindsborg, Kan.
Dellinger, Orris P., Ph. D., 1909, prof. biology, K. S. T. C., Pittsburg, Kan.
Dunlevy, R. B., M. A., 1896, Southwestern Col., Winfield, Kan.
Eby, J. Whit, B. S., 1903, banker, Howard, Kan.
Failyer, George H., M. S., 1878, retired, R. R. 4, Manhattan, Kan.
Faragher, Warren F., Ph. D., 1927, dir. of Research Catalytic Dev. Co., 1608 Walnut street, Philadelphia, Pa.
Garrett, A. O., M. A., 1901, head Dept. Biology, East High School, Salt Lake City, Utah.
Graham, I. D., M. S., 1879, State Board of Agric., Topeka, Kan.
Harman, Mary T., Ph. D., 1912, prof. zoölogy, K. S. C., Manhattan, Kan.
Harnly, Henry J., Ph. D., 1893, prof. biology, McPherson Col., McPherson, Kan.
Harshbarger, William A., Sc. D., 1903, prof. mathematics, Washburn Col., Topeka, Kan.
Havenhill, L. D., Ph. C., 1904, dean School of Pharmacy, U. of K., Lawrence, Kan.

King, H. H., Ph. D., 1909, prof. and head Dept. Chemistry, K. S. C., Manhattan, Kan.
Meeker, Grace R., 1899, 709 S. Mulberry, Ottawa, Kan.
Menninger, C. F., M. D., 1903, 3617 W. Sixth avenue, Topeka, Kan.
Nabours, Robert K., Ph. D., 1910, prof. and head Zoölogy Dept., K. S. C., Manhattan, Kan.
Nissen, A. M., A. B., 1888, farmer, Wetmore, Kan.
Peace, Larry M., 1904, 512 W. Ninth street, Lawrence, Kan.
Reagan, Mrs. Otilla, 1937, Provo, Utah.
Robertson, W. R. B., Ph. D., 1905, Anat. Dept., Univ. Iowa, Iowa City, Iowa.
Schoewe, Walter, H., Ph. D., 1925, Dept. Geology, U. of K., Lawrence, Kan.
Scheffer, Theodore, M. A., 1903, assoc. biologist, U. S. Biological Survey, Puyallup, Wash.
Shirk, J. A. G., 1904, prof. mathematics, K. S. T. C., Pittsburg, Kan.
Smith, Alva J., 1892, consulting eng., 810 Boylston street, Pasadena, Cal.
Smyth, E. Graywood, 1901, consulting entomologist, Hillcrest Ranch, Glen Ellen, Cal.
Sternberg, Charles H., M. A., 1896. Address unknown.
Stevens, Wm. C., 1890, 1121 Louisana street, Lawrence, Kan.
Welin, John Eric, D. Sc., 1889, prof. chemistry, Bethany Col., Lindsborg, Kan.
Wells, J. R., Ph. D., 1934, prof. biology, K. S. T. C., Pittsburg, Kan.
Willard, Julius T., D. Sc., 1883, college historian, K. S. C., Manhattan, Kan.
Wilson, William B., Sc. D., 1903, held Biology Dept., Ottawa Univ., Ottawa, Kan.
Wooster, Lyman C., Ph. D., 1017 Union street, Emporia, Kan.

ANNUAL MEMBERS

Members who paid their 1939 dues before April 10, 1939, are indicated by an asterisk (*). The year given is that of election to membership. If two years are given, the second signifies reinstatement. All addresses are Kansas unless indicated otherwise.

*Abbott, Earl, 140 S. Green, Wichita.
Abernathy, George Elmer, Ph. D., 1938, geologist, Kansas State Geological Survey, Pittsburg.
*Ackert, James E., Ph. D., 1917, prof. zoölogy, dean Graduate Division, K. S. C., Manhattan.
*Agnew, Hugh H., B. S., 1939, 413 W. Fifth, Hays.
*Aicher, L. C., B. A., 1930, supt. Fort Hays Branch, K. S. A. Expt. Sta., Hays.
*Albertson, F. W., Ph. D., 1935, prof. botany, F. H. K. S. C., Hays.
*Albertson, Maurice, student, 1938, 201 W. Twenty-first, Hays.
*Albright, Penrose, S., Ph. D., 1926, asst. prof. physics and chem., Southwestern Col., Winfield.
Alexander, Stanley, B. S., 1938. Address unknown.
*Allegre, Charles F., B. S., 1935, 302 S. Sixth street, Osage City.
*Allen, Merle W., M. S., 1938, Coffeyville Junior College, Coffeyville.
Allen, Paul B., M. S., 1938, principal Ottawa Public Schools, Ottawa.
*Alm, O. W., Ph. D., 1931, assoc. prof. psychology, K. S. C., Manhattan.
*Alsop, Annette, B. S., 1937, K. S. C., 901 Osage, Manhattan.
*Ameel, Donald J., Sc. D., 1937, inst. zoölogy, K. S. C., Manhattan.
*Angelica, Sister, 1939, 4530 Perrysville Road, Northside Belleview Branch, Pittsburgh, Pa.
*Andrews, Theodore F., student, 1938, K. S. T. C., 1010 Union street, Emporia.
Angell, Wenonah E., 1936, Medicine Lodge.
*Arkansas General Library, 1938, Univ. of Arkansas, Fayetteville, Ark.
*Babcock, Rodney W., Ph. D., 1931, dean Div. Gen. Sci., K. S. C., Manhattan.
Baden, Martin W., Sc. D., 1921, Box 520, Winfield.
Bailey, Lorene, M. S., 1932, 3005 Stevens, Parsons.
*Barnett, R. J., M. S., 1922, prof. horticulture, K. S. C., Manhattan.
Barnhart, Carl, B. S., 1932, instr. H. S. East, Wichita.
*Barton, Arthur W., Ph. D., 1928, head of Botany Dept. F. H. K. S. C., Hays.
*Bates, James C., Ph. D., 1933, asst. instr. botany, K. S. C., Manhattan.
*Bawden, William T., Ph. D., 1938, head dept. Indus. and Vocational Education, K. S. T. C., Pittsburg.
*Bayles, Ernest E., Ph. D., 1936, assoc. prof. education, U. of K., Lawrence.
*Beach, Edith, M. A., 1931, 812 Illinois street, Lawrence.
*Beamer, R. H., Ph. D., 1936, 1939, 1000 Missouri, Lawrence.
*Beck, Gladys, M. S., 1937, Wyandotte High School, Kansas City.

*Becker, Glenn V., 1939, senior, Bethel College, North Newton.
*Bennett, Dewey, M. A., 1928, instr. biology and chem., Jr. Col., Garden City.
*Bennington, Ross, 1939, Pittsburg, R. R. 4.
*Berger, Carl W., B. S., 1938, petroleum chemist, McPherson.
*Bergstresser, Karl S., Ph. D., 1937, head Chem. Dept., Ottawa University, Ottawa.
*Beyer, Roy R., B. S., assistant in pharmacy, 1939, 1125 Vermont, Lawrence.
*Bice, Claude W., 1939, student, box 123, Hays.
*Blackman, Leslie E., Ph. D., 1935, head Dept. Chem., K. S. T. C., Emporia.
*Blanchard, Lloyd M., 1938, 912-914 Kansas ave., engr. geology, WPA of Kansas, Topeka.
*Booth, W. E., M. S., 1939, botany, U. of K., Lawrence.
*Bottenfield, Mable Owen, M. S., 1938, 507 Quincy, Pittsburg.
*Bottom, V. E., M. S., 1939, Friends University, Wichita.
*Boughton, L. L., M. S., 1929, asst. prof. pharmacy, U. of K., Lawrence.
*Boyce, Earnest, M. S., in Eng., 1939, prof. sanitary engineering, Uni. of K., Room 2, Marvin Hall, K. U., Lawrence.
*Bowman, J. L., M. S., 1928, prof. physics, McPherson College, McPherson.
*Brownlee, J. A., A. M., 1930, 340 N. Ash, Wichita.
Brady, Miss Laurane, B. S., 1938, Conception, Mo.
*Branch, Hazel E., Ph. D., 1924, prof. zoölogy, Univ. of Wichita, Wichita.
*Branson, Delmar, A. B., 1938, student K. U., 1121 S. Fifth street, Osawatomie.
*Branson, Lester R., B. S., 1938, student, Coats.
Brazil, James, A. B., 1938, 37 Sharice Karrel Nil, Cairo, Egypt.
Breithaupt, Gail M., M. S., 1938, 217 N. Popular, Edgerton.
Brennan, L. A., M. S., 1933, principal high school, Andale.
*Breukelman, John, Ph. D., 1930, prof. biology, K. S. T. C., Emporia.
*Brewster, Ray Q., Ph. D., 1919, prof. chemistry, U. of K., Lawrence.
*Bridwell, Arthur, A. B., 1937, collector geol. spec., K. U. Museum, Baldwin City.
*Brigden, Robert L., Ph. D., 1931, Wichita Child Guidance Center, Wichita.
*Brooks, C. H., M. S., 1929, 1938, Extension Division, F. H. K. S. C., Hays.
*Brooks, Travis E., student, 1937, K. S. C., Manhattan.
*Brown, Harold P., Ph. D., 1934, prof. chemistry, Univ. Kansas City, Kansas City, Mo.
*Brownlee, J. A., A. M., 1937, 340 N. Ash street, Wichita.
*Brubaker, H. W., Ph. D., 1929, prof. chem., K. S. C., Manhattan.
*Brumwell, Malcolm J., 1939, student, 700 Mississippi, Lawrence.
*Bryson, Harry R., M. S., 1933, asst. prof. entomology, K. S. C., Manhattan.
*Bugbee, Robert E., Ph. D., 1937, College of Emporia, Emporia.
Burford, Wesley R., student, 1937, F. H. K. S. C., Hays.
*Burke, Miss Cecelia, B. S., 1938, Mount St. Scholastica College, Atchison.
Burnett, R. Will, B. A., 1938. Address unknown.
*Burt, Charles E., Ph. D., 1932, prof. biology, Southwestern College, Winfield.
*Burt, Lucile, A. M., 1937, botany, K. S. C., Manhattan.
*Butler, John Earl, 1939, student, Stockton.
Calhoun, Arthur W., Ph. D., 1937, dean and prof. psychology and philosophy, Sterling College, Sterling.
Calkins, Edward Jesse, M. S., 1938, asst. prof. education, K. S. T. C., Emporia.
*Call, L. E., M. S., 1922, dean Division of Agri., dir. Agr. Exp. Sta., K. S. C., Manhattan.
*Campbell, Marion I., M. S., 1929, Topeka State Hospital, Topeka.
*Cardwell, A. B., Ph. D., 1937, head Dept. Physics, K. S. C., Manhattan.
*Carpenter, Albert C., 1929, president Lesh Oil Co., Ottawa.
*Carpenter, Pearl, M. A., 1939, 1611 New Hampshire, Lawrence.
Carroll, Jane, B. S., 1938, prof. elementary education, K. S. T. C., Pittsburg.
*Carter, F. L., 1939, teacher biology, H. S., Wilson.
Carter, Vernon L., B. S., 1937, instr. science, Oxford.
*Case, Arthur A., B. S., 1938, grad. res. asst. in zoölogy, K. S. C., Manhattan.
Chapin, Ernest K., M. S., 1934, assoc. prof. physics, K. S. C., Manhattan
*Chapman, O. W., Ph. D., 1938, prof. chem., K. S. T. C., Pittsburg.
*Chapman, Seville, Ph. D., 1939, instr. physics, K. U., Lawrence.
*Choguill, Harold S., A. M., 1934, 210 N. Tenth street, Independence.
*Clark, Francis E., Ph. D., 1939, 1210 Bertrand street, Manhattan.
*Clark, J. Tate, A. B., 1937, Phillips Petroleum Co., 722 Nixon Bldg., Corpus Christi, Texas.

Coco, Russell M., M. S., 1932, Dept. of Zoölogy, Univ. of Louisiana, Baton Rouge, La.
*Cohoe, Edith, M. S., 1938, 15370 Farrer, Detroit, Mich.
*Colyer, E. E., A. M., 1937, head Dept. of Math., F. H. K. S. C., Hays.
*Connecticut State College Library, 1937, Storrs, Conn.
*Conover, Robert W., M. A., 1939, prof. English, K. S. C., Manhattan.
*Cook, Charles Wayne, 1939, student, 429 W. Eleventh, Hays.
*Cooper, Arthur A., 1939, student, Lewis Field, Hays.
Corey, William Lee, D. C. and M. D., 1937, 3824 Highland Ave., Kansas City, Mo.
*Cotton, Richard T., 1935, senior ento., U. S. D. A., Manhattan.
*Coventry, Margaret, M. S., 1938, instr. chem., K. S. T. C., Pittsburg.
*Cowan, Edwina, Ph. D., 1929, dir. Wichita Child Guidance Center, Wichita.
*Cressler, Lawrence, 1939, student, 410 W. Eleventh, Hays.
*Cram, S. Winston, Ph. D., 1937, prof. physics, K. S. T. C., Emporia.
*Crow, H. Ernest, Ph. D., 1926, prof. biology, Friends Univ., Wichita.
*Cunningham, Arleigh, B. S., 1937, Miller High School, Miller.
*Cunningham, Chester B., M. A., 1938, instr. physics, Lawrence.
*Curtiss, Charles, A. B., 1938, grad. student ento., K. S. C., Manhattan.
*Dalton, Standlee, M. S., 1937, dept. of zoölogy, F. H. K. S. C., Hays.
*Dashen, Ludwig, M. A., 1937, science inst., Lyons H. S., 709 W. Lyons, Lyons.
*Davidson, Arthur W., Ph. D., 1927, assoc. prof. chem., U. of K., Lawrence.
*Davis, Philip B., student, 1938, Laverne, Cal.
*Dennis, Parley W., M. S., 1936, 212 E. Cottonwood, Independence.
Dewitt, Jack, M. S., 1938, instr., Fort Scott Jr. Col., Fort Scott.
*Dickinson, F. H., M. S., 1938, asst. prof. ind. and voc. edu., K. S. T. C., Pittsburg.
*Dickman, Sister Regina Marie, M. S., 1937, instr. foods, Marymount Col., Salina.
*Dill, Florence E., A. B., 1938, grad. student, 1301 Ohio street, Lawrence.
*Dillon, Franklin, M. S., 1938, 2109 University, Wichita.
*Dobrovolny, Charles G., M. S., 1930, dept. zoölogy, Univ. of Mich., Ann Arbor, Mich.
*Doell, J. H., Ph. D., 1926, prof. biology, Bethel College, North Newton.
*Doering, Kathleen, C., Ph. D., 1939, asst. prof. ento., 1214 Tennessee street, Lawrence.
*Downs, Ted, 1939, student, K. S. T. C., Emporia.
Douglass, J. R., M. S., 1928, assoc. ento., box 1100, U. S. Bur. Ent. and P. Q., Twin Falls, Idaho.
*Drake, Ralph L., M. D., 1938, psychiatrist, Wichita Child Res. Lab., Brown bldg., Wichita.
*Dresher, C. H., B. S., 1930, 320 N. Maxwell, McPherson.
*Driver, D. D., A. M., 1938, instr. in math. and phys. sci., Hesston.
Dunbar, Irene W., B. S., 1938, 407 S. Elm St., Pittsburg.
*Dunmire, Harriett, 1939, Psychometrist, Wichita Child Guidance Center, Friends Univ., Wichita.
*Durell, William Donald, B. S., 1938, instr. botany, 648 Tennessee street, U. of K., Lawrence.
Dutro, Ruth, A. B., 1938, 499 S. Market street, Hagerstown, Ind.
Edberg, Harold, B. S., 1938, student, Hackley.
*Eades, Jack, student, 1939, Stockton.
*Edgar, Allen, student, 1938, Dept. Zoölogy, K. S. C., Manhattan.
*Ellis, Ralph, 1935, 2420 Ridge road, Berkley, Cal.
*Elwell, Leonard H., M. S., 1938 and 1939, 250 E. Seventy-fourth street, New York City, N. Y.
*Embich, Major John R., M. S,. 1938, Fort Riley.
*Emery, Albert T., N. D., 1938, 222 E. Eleventh street, Kansas City, Mo.
*Emery, W. T., M. A., 1928, asst. entomologist, U. S. D. A., Manhattan.
*Enberg, L. A., 1935, The Carey Salt Co., Hutchinson.
*Eubanks, James, 1939, student, Morganville.
Enders, John W., 1938, student, Lyons.
*Ericson, John, 1939, student, 835 Lindenwood Ave., Topeka.
*Evers, Robert A., B. S., 1931, 1803½ State street, Quincy, Ill.
*Farrell, F. D., D. Agr., 1924, president, K. S. C., Manhattan.
*Fellows, Hurley, Ph. D., 1938, assoc. pathologist, U. S. D. A., K. S. C., Manhattan.
*Fent, Lee S., B. S., 1939, grad. asst. zoölogy, K. S. C., Box 13, K. S. C., Manhattan.
*Ficke, C. H., M. S., 1938, junior pathologist, U. S. D. A., Botany Dept., K. S. C., Manhattan.
*Filinger, George A., Ph. D., 1932, asst. prof. pomolgy, K. S. C., Manhattan.

*Finerty, Jack, A. B., 1938, grad. asst. zoölogy, K. S. C., Manhattan.
*Fiss, Fred H., B. S., 1939, 1120 Kansas avenue, Atchison.
*Fletcher, Hazel M., Ph. D., 1937, res. asst., home ec., K. S. C., Manhattan.
Fletcher, Worth, Ph. D., 1928, prof. chem., Univ. Wichita, Wichita.
*Flora, S. D., 1934, meteorologist, U. S. Weather Bureau, Topeka.
*Frain, Kenneth, B. S., 1938, student Bethany College, Lindsborg.
Francis, L. D., Ph. D., 1938, assoc. prof. home ec., K. S. T. C., Pittsburg.
*Fraser, Rev. S. V., 1931, Aurora.
Frazier, J. C., M. A., 1937, instr. bot., K. S. C., Manhattan.
*Frick, Lyman P., A. B., 1939, grad. res. assist. zoöl., K. S. C., Manhattan.
*Friesen, Abraham P., 1936, head Dept. Physics, Bethel College, North Newton.
*Fritz, Foy F., B. S., 1938, grad. student, K. S. C., Manhattan.
*Gates, David M., 1939, student, 1515 Humboldt, Manhattan.
*Gates, F. C., Ph. D., 1922, prof. botany, K. S. C., Manhattan.
*Gentry, Adrian N., M. A., 1938, 412 S. Ash street, Ottawa.
*Geldreich, Edward W., 1939, inst. psych., K. S. T. C., Emporia, 1428 State St., Emporia.
*Gessner, B. A., Ph. D., 1937, prof. of psyych., Baker Univ., Baldwin.
*Geir, L. J., M. S., 1931, Campbell College, Buies Creek, N. C.
*Giersch, Sister Crescentia, M. S., 1934, instr. biology, Marymount Col., Salina.
Gilbert, Lael O., A. B., 1938, student, F. H. K. S. C., Hays, 508 Walnut, Hays.
*Ginsberg, Norman, M. D., 1939, inst. anatomy dept., U. of K., Lawrence.
*Gladfelter, C. F., 1936, M. S., instr. agri., 1012, Market street, Emporia.
*Glover, J. A., A. B., 1934, chemistry, H. S. North, Wichita.
*Glaze, J. A., Ph. D., 1939, K. S. T. C., Pittsburg.
*Goff, Richard, student, 1937, Dept. of Zoölogy, Univ. of Oklahoma, Norman, Okla.
Good, Wilfred M., A. B., 1938, asst. instr., U. of K., Lawrence.
Gooden, Don., B. S., 1938, principal Jr. H. S., Mound City.
Gordon, Carl E., student, 1938, 153 S. Volutsia, Wichita.
*Gordon, Glen H., A. B., 1938, geologist Magnolia Petroleum Co., 158 S. Volutsia, Wichita.
Gorham, Maude I., A. M., 1936, prof., F. H. K. S. C., Hays.
Graham, Edward W., B. S., 1938, grad. student, K. S. T. C., Pittsburg, 206 W. First, Pittsburg.
Gray, William H., 1937, Dept. Psychology, K. S. T. C., Emporia.
Griffith, Melvin E., A. M., 1938, Dept. of Zoölogy, Agricultural College, Fargo, N. Dak.
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Bavaria H. S. Junior Science Club, 1938, Bavaria.
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*Burlingame Biology Club., 1939; Dolf J. Jennings, Burlingame.
*Burlington H. S. Science Club, 1939; Charles F. Allegre, sponsor, 302 S. Sixth, Burlington.
*Cherryvale S. F. A. Science Club, 1938; Warren Willey, sponsor, Cherryvale.
*Caldwell High School, 1939, Caldwell.
*Columbus H. S. Jr. Science Club, 1938; K. A. McClure, sponsor, Columbus.
*Fort Scott High School Science Club, 1938; Ross Anderson, sponsor, Fort Scott.
*Galena High School Science Club, 1938; Robert Troughton, sponsor, Galena.

*Girard High School Science Club, 1939; W. V. McFerrin, 614 S. Cherokee street., Girard.
*Hill City Memorial High School Science Club, 1939; William Voss, sponsor, Memorial High School, Hill City.
*Independence General Science Club, 1938; Parley W. Dennis, sponsor, Independence.
*Iola Jr. High School Science Club, 1938; Seth J. Owens, sponsor, Iola.
*Junction City Jr. Sr. High Science Club, 1934; H. R. Callahan, sponsor, Junction City.
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*Manhattan High School Science Club, 1938; Ralph Rogers, sponsor, Manhattan.
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Smith, R. G., Ph. D., 1938, prof. math., Pittsburg.
*Smith, Steve, 1938, mgr. Photographic Dept., Hall's, Topeka, 623 Kansas avenue, Topeka.
Smith, V. T., Ph. D., 1937, Kansas Wesleyan Univ., Salina.
*Snapp, Glenn B., B. S., 1939, Belleville.
*Speery, Arthur B., B. S., 1917, 1922, prof. geology, K. S. C., Manhattan.
*Sprague, James, A. B., 1938, Dept. Zool., U. of K., Lawrence.
*Stark, Frank L., B. S., 1938, junior high and grade principal, Cedarvale.
*Stebbins, Florence M., M. S., 1933, asst. genetics, K. S. C., Manhattan.
*Stephens, Homer A., B. S., 1936, 320 Santa Fe, Atchison.
Stephenson, Lyle A., 1932, 118 E. Tenth street, Kansas City, Mo.
*Sternberg, Charles H., 1936, 220 Westlake avenue, Hays, care Oliver Sternberg.
*Sternberg, George F., M. S., 1928, field vertebrate paleontologist, F. H. K. S. C., Hays.
Stewart, Troy J., B. A., 1938, student, 141 N. Hillside, Wichita.
*Stockebrand, F. C., B. S., 1938, teacher biology, Fort Scott.

Stogsdill, J. W. E., A. B., 1929, 1937, Dept. Physics, East High School, Wichita.
*Stoland, O. O., Ph. D., 1939, prof. physiology, 1845 Lernard, Lawrence.
*Stoltz, Martha, M. S., 1939, Chanute Jr. College.
*Storer, W. W., Ph. D., 1939, assoc. prof. astronomy, 1716 Mississippi street, Lawrence.
*Stouffer, E. B., Ph. D., 1929, dean, Grad. School, U. of K., Lawrence.
*Stratton, Geo. W., Ph. D., 1939, prof. chem., Bailey Chemical Lab., K. U., Lawrence.
*Stratton, W. T., Ph. D., 1939, prof. and head math., K. S. C., Manhattan.
Street, C. W., Ph. D., 1938, head Dept. of Educa., K. S. T. C., Pittsburg.
*Studt, Charles W., M. S., 1928, 1212 N. Second street, Independence.
*Sturmer, Anna Marie, A. M., 1939, assoc. prof. English, K. S. C., Manhattan.
*Sutter, L. A., M. D., 1923, physician, 611 First National Bank bldg., Wichita.
*Swanson, Arthur F., M. S., 1926, agronomist, Branch Exp. Sta., Hays.
*Taft, Robert, Ph. D., 1923, 1929, assoc. prof. chem., U. of K., Lawrence.
*Taggart, Kathryn, A. B., 1934, 1939, 1262 Boswell, Topeka.
Talbott, W. A., Jr., 1935, 411 Pearl street, Joplin, Mo.
*Taylor, Edward H., Ph. D., 1928, assoc. prof. zoöl., U. of K., Lawrence.
*Taylor, William Ralph, 1939, student, Museum of Vertebrate Paleontology, U. of K., Lawrence.
*Ter Keurst, Arthur J., Ph. D., 1939, prof. of educ., Col. of Emporia, 1019 W. street, Emporia.
Teller, James H. D., Ph. D., 1938, instr. math., F. H. K. S. C., Hays.
Terry, Lyman, student, 1937, 1704 Kentucky street, Lawrence.
*Thompson, D. Ruth, M. A., 1928, prof. chem., Sterling College, Sterling.
Thompson, Rufus H., M. A., 1934, Dept. Botany, U. of K., Lawrence.
*Tiemeier, Otto W., A. B., 1937, museum asst., U. of K., Lawrence.
*Tihen, Joe A., 1936, Harper.
Todd, Arlie, A. B., 1938, Dept. Zoöl., Univ. of Nebraska, Lincoln, Neb.
*Tooney, Rex, 1939, Dept. Chem., K. S. C., Manhattan.
*Torstveit, Olaf, M. S., 1937, Dept. Zoöl., U. of Wis., Madison, Wis.
*Travis, Gerald, B. S., 1937, principal Norton H. S., Norton.
*Trent, J. A., A. M., 1934, asst. prof. biology, K. S. T. C., Pittsburg.
*Tuck, J. B., 1938, Dept. Ent., K. S. C., Manhattan.
Tucker, Charles B., M. S., 1938, instr. math., K. S. T. C., Emporia.
Tusler, Orlando, C., B. S., 1938, 1042 N. Broadway, Wichita.
*Urich, Jocob, Ph. D., 1938, instr. zoöl., K. S. T. C., Pittsburg.
Vandervelde, Conrad, D. D., 1937, dean, psychology, College of Emporia, Emporia.
*Voth, Albert C., 1936, 1939, Menninger Sanitarium, Topeka.
*Wadley, F. M., Ph. D., 1938, U. S. Bur. Ent. and Pl. Quar., U. S. D. A., Washington, D. C.
*Wagoner, C. E., 1938, student, McPherson College, McPherson.
*Walkden, H H., B. S., 1938, U. S. D. A. Bur. Ent. and Pl. Quar., 1204 Fremont street, Manhattan.
*Walling, Lelia V., M. A., 1939, asst. prof., 1242 Louisiana street, Lawrence.
*Waring, Sister Mary Grace, Ph. D., 1932, head science, Marymount College, Salina.
Warner, Robert W., E. E., 1935, head elect. engr., U. of Texas, Austin, Texas.
*Way, P. Ben, B. S., 1932, High School North, Wichita.
*Weathers, Edra, A. B., 1936, Wichita Child. Res. Lab., Friends Univ., Wichita.
*Webb, John, student, 1939, F. H. K. S. C., 429 W. Eleventh, Hays.
*Weber, Arthur D., M. S., 1937, Dept. Animal Hus., K. S. C., Manhattan.
*Weber, Clement, 1928, box 186, Selden.
*Weber, Louis R., Ph. D., 1929, head physics, Friends Univ., Wichita.
Weeks, Elvira, Ph. D., 1927, asst. prof. chem., U. of K., Lawrence.
*Weidlein, Edward Ray, Sc. D., LL. D., 1911, dir. Mellon Inst., Mellon Inst., Pittsburgh, Pa.
*Weishapl, Catherine, B. S., 1938, Herndon.
*Weimer, Paul K., A. M., 1939, prof. phys. science, Tabor College, Hillsboro.
*West, Marion C., 1938, Dept. Ent. and Zoöl., U. of Cal., Davis, Cal.
Wetmore, Alexander, 1935, asst. sec. Smithsonian Inst., U. S. Nat. Museum, Washington, D. C.
*Westgate, Earle W., M. A., 1939, 509 Parallel, Atchison.
*Wheatley, Max D., A. B., 1938, asst. instr., zoöl., U. of K., Lawrence.
*Wheeler, Raymond H., Ph. D., 1936, prof. and head psych., U. of K., Lawrence.
White, June, B. S., 1938, 2110 W. Garfield boulevard, Chicago, Ill.

*White, Otis, M. S., 1939, Dexter.
*White, Leland, M. A., 1939, asst. instr. chem., K. U., Lawrence.
*Whitla, Raymond E., A. B., 1937, asst. prof. geol., U. of K., Lawrence.
*Whitney, Marion I., Ph. D., 1938, asst. prof. of geology, K. S. T. C., Pittsburg.
*Wilbur, Donald A., A. M., 1934, asst. prof. ent., K. S. C., Manhattan
*Willis, Clifford L., B. S., 1939, asst. instr. geol., 1140 Louisiana street, Lawrence.
Wimmer, E. J., Ph. D., 1928, asst. prof. zoöl., K. S. C., Manhattan.
*Wismer, C. A., M. S., 1933, Exp. Sta. of the Hawaii Sugar Planters' Assoc., Honolulu, T. H.
*Wismer, Nettie M., M. B., 1932, 1939, 342 Johnson avenue, Lawrence.
Witherspoon, Ward, A. B., 1936, 1121 Waverly, Kansas City.
*Wolfson, Charles, instr. anatomy, K. U., 1935, 1939, Lawrence.
*Wood, Robert E., M. S., 1930, chem., Liberty Memorial H. S., Lawrence.
*Woodruff, Laurence C., Ph. D., 1939, asst. prof. ento., 309 Snow Hall, Lawrence.
*Woodward, Parke, M. D., 1939, assoc. prof. phys., 1743 Louisiana street, Lawrence.
*Wooster, L. D., Ph. D., 1924, prof. zoöl., F. H. K. S. C., Hays.
*Yoder, Emerson, 1938, student, McPherson College, or Windom.
*Yoder, Maurice A., M. S., 1938, Hesston.
Yoder, J. J., LL. D., 1926, prof. soc., McPherson Col., McPherson.
*Young, Roger L., 1938, 118 E. Eleventh street., Lawrence.
*Young, Clinton M., E. M., 1939, prof. mining and metallurg. eng., Lawrence.
*Zinszer, Harvey A., Ph. D., 1930, prof. physics and astron., F. H. K. S. C., Hays.
*Zinszer, Richard H., Ph. D., 1931, 950 Fries street, Wilmington, Cal.
*Zinszer, Wm. K., A. B., 1938, 401 W. Twelfth street, Hays.

SEVENTY-FIRST ANNUAL MEETING

KANSAS ACADEMY OF SCIENCE

Kansas University, Lawrence, Kan., March 30, 31, April 1, 1939

OFFICERS OF THE ACADEMY

W. H. SCHOEWE, President, University of Kansas, Lawrence.
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E. O. DEERE, Vice-president, Bethany College, Lindsborg.
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H. A. ZINSZER, Treasurer, Fort Hays Kansas State College, Hays.

Additional Members of Executive Council

GEO. A. DEAN, Kansas State College, Manhattan.
LAWRENCE ONCLEY, Greencastle, Ind.
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EDITORIAL BOARD

F. C. GATES, Editor, Kansas State College, Manhattan. Term expires 1941.
W. J. BAUMGARTNER, Managing editor, University of Kansas, Lawrence. Term expires 1940.

ASSOCIATE EDITORS

R. E. MOHLER, McPherson College, McPherson. Term expires 1941.
LOUIS R. WEBER, Friends University, Wichita. Term expires 1939.
ROBERT TAFT, University of Kansas, Lawrence. Term expires 1941.
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Botany: C. C. McDONALD, Wichita.
Chemistry: FAYETTE T. OWEN, Emporia.
Entomolgy: L. C. WOODRUFF, Lawrence.
Geology: D. C. SCHAFFNER, Emporia.
Junior Academy: BILL OKEY, Pittsburg.
Physics: PENROSE S. ALBRIGHT, Winfield.
Psychology: JOSEPH W. NAGEE, Emporia.
Science Teachers, Biology: LORENE BAILEY, Parsons.
Science Teachers, Physical Science: LAWRENCE ONCLEY, Geencastle, Ind.
Zoölogy: EARL HERRICK, Manhattan.

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3. Junior Academy

Edith Beach, Chairman, University of Kansas, Lawrence.
J. R. Wells, Kansas State Teachers College, Pittsburg.
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4. Coördination of Scientific Groups

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J. B. Stroud, Kansas State Teachers College, Emporia.
W. J. Baumgartner, University of Kansas, Lawrence.
Lloyd McKinley, University of Wichita, Wichita.
Rodney Babcock, Kansas State College, Manhattan.

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W. J. Baumgartner, Chairman, University of Kansas, Lawrence.

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Institutional Representatives

Mary Larson,
Ward Overholt.
J. E. Ackert.
C. E. Lane.
Clara Hartley.
E. O. Deere.
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W. S. Long.
J. H. Doell.
Sister Mary Waring.
J. W. Hershey.
Sister Anthony Payne.
Wm. B. Wilson.
Paschal H. Pretz.
Sister Agnes Marie Horner.
D. Ruth Thompson,
R. B. Dunlevy.
J. C. Schmidt.

7. Committee on Necrology

L. D. Bushnell, Kansas State College, Manhattan, Chairman.
Roy Rankin, Fort Hays Kansas State College, Hays.
H. J. Harnley, McPherson College, McPherson.

8. Committee on Educational Trends

J. A. Glaze, Chairman, Kansas State Teachers College, Pittsburg.
O. W. Alm, Kansas State College, Manhattan.

9. COMMITTEE ON RESEARCH AND RESEARCH AWARDS

L. D. WOOSTER, Chairman, Fort Hays Kansas State College, Hays.
R. Q. BREWSTER, University of Kansas, Lawrence.
J. C. PETERSON, Kansas State College, Manhattan.
P. G. ALBRIGHT, Southwestern College, Winfield.

10. COMMITTEE ON NATURAL HISTORY HANDBOOKS

F. C. GATES, Chairman, Kansas State College, Manhattan.
D. C. SCHAFFER, College of Emporia, Emporia.
R. BEAMER, University of Kansas, Lawrence.
E. J. WIMMER, Kansas State College, Manhattan.

11. PROGRAM COMMITTEE

ROGER C. SMITH, Kansas State College, Chairman.
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O. W. ALM, Kansas State College, Manhattan.
R. H. WHEELER, University of Kansas, Lawrence, Chairman of Local Committee.
E. E. BAYLES, University of Kansas, Lawrence.
(With Chairmen of Sections.)

12. COMMITTEE ON NEW SECTIONS

E. O. DEERE, Bethany College, Lindsborg, Chairman.
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H. H. HALL, Kansas State Teachers College, Pittsburg.
W. H. SCHOEWE, University of Kansas, Lawrence.
ROGER C. SMITH, Kansas State College, Manhattan.

13. COMMITTEE ON SCIENCE TEACHING

E. E. BAYLES, University of Kansas, Lawrence, Chairman.
E. H. KROEKER, Bethel College, North Newton.
R. LITWILLER, Kansas Wesleyan, Salina.
H. E. SCHRAMMEL, Kansas State Teachers College, Emporia.
J. A. TRENT, Kansas State Teachers College, Pittsburg.
L. E. HUDIBURG, Kansas State College, Manhattan.
G. A. KELLY, Fort Hays Kansas State College, Hays.
L. ONCLEY, Southwestern College, Winfield.
LORENE BAILEY, Parsons Junior College, Parsons.

14. COMMITTEE ON COÖRDINATING FINANCE

H. ZINSZER, Fort Hays Kansas State College, Hays, Chairman.
W. E. GRIMES, Kansas State College, Manhattan.
R. TAFT, University of Kansas, Lawrence.
C. E. RARICK, Fort Hays Kansas State College, Hays.
W. J. BAUMGARTNER, University of Kansas, Lawrence.

15. COMMITTEE ON PUBLICATION FUND

C. E. RARICK, Fort Hays Kansas State College, Hays, Chairman.
H. ZINSZER, Fort Hays Kansas State College, Hays.
A. W. BARTON, Fort Hays Kansas State College, Hays.
F. W. ALBERTSON, Fort Hays Kansas State College, Hays.
F. B. LEE, Fort Hays Kansas State College, Hays.

16. Auditing Committee

A. Bernhart, Ottawa University, Ottawa, Chairman.
W. A. Harshbarger, Washburn College, Topeka.
E. R. Lyon, Kansas State College, Manhattan.

17. Resolutions Committee

O. P. Dellinger, Kansas State Teachers College, Pittsburg, Chairman.
R. E. Bugbee, College of Emporia, Emporia.
Bernice Kunerth, Kansas State College, Manhattan.

18. Local Committee

R. H. Wheeler, University of Kansas, Lawrence, Chairman.
W. J. Baumgartner, University of Kansas, Lawrence.
C. Hibbard, University of Kansas, Lawrence.
J. M. Jewett, University of Kansas, Lawrence.
M. W. Mayberry, University of Kansas, Lawrence.
Edith Beach, Lawrence.

19. Nominating Committee

W. H. Matthews, Kansas State Teachers College, Pittsburg, Chairman.
J. W. Hershey, McPherson College, McPherson.
W. J. Baumgartner, University of Kansas, Lawrence.
L. Oncley, Southwestern College, Winfield.
G. A. Dean, Kansas State College, Manhattan.

PROGRAM OUTLINE

Thursday, March 30

2:30 p. m. Executive Council Meeting, Haworth Hall, Room 202.

4:00 p. m. to 9:15 p. m. Registration in Union Building, Main Floor.

7:30 u. m. Lecture by Dr. Charles A. Shull, University of Chicago. Subject: "The Plant in Relationship to the Water System of Its Environment." This lecture is sponsored by the Kansas chapters of Phi Sigma and Sigma Xi and the Kansas Academy of Science. Fraser Hall.

9:00 p. m. General Reception for all members and visitors, Union Building.

Friday, March 31

8:00.a. m. to 5:00 p. m. Registration, Snow Hall.
- Senior Academy, Room 321.
- Junior Academy, Room 323.
- Exhibits, Snow Hall, Room 220.

9:00 a. m. to 10:45 a. m. Sectional Meetings.
- Botany, Snow Hall, Room 417.
- Zoölogy, Snow Hall, Room 101.
- Geology, Haworth Hall, Room 101.
- Psychology, Frank Strong Hall, Room 9.
- Archeology, Snow Hall, Room 502.
- Junior Academy, Chemistry Building, Room 305.

11:00 a. m. General Session, Marvin Hall, Room 206.

1. Announcements—President Schoewe.
2. Reports of the recipients of the 1938 Research Awards.
   F. C. Gates—Distribution of Flowering Plants and Ferns in Kansas.
   Mary T. Harman—Development of Pigment in Hair and Skin of Guinea Pigs.
   Harry R. Bryson—Elateridae of Kansas.
   Roger C. Smith—Identification of Eggs of Middle West Grasshoppers. (Report presented by J. B. Tuck.)
   Edwina A. Cowan—Test Method of Determination of Constitutional Type.
   John Breukelman—Distribution of Kansas Fishes.
3. Reports of officers—President, W. H. Schoewe; President Elect, H. H. Hall; Vice-president, E. O. Deere; Secretary, Roger C. Smith; Treasurer, H. A. Zinszer; Editor, F. C. Gates; Managing Editor, W. J. Baumgartner.
4. Report of the delegate to the Richmond Academy Conference—H. A. Zinszer, delegate.
   Report of delegate to the University of Köln 550th year celebration. Miss Margaret Newcomb.
5. "Demonstration-lecture on color photography" by Oren Bingham, University of Kansas.
6. "Demonstration of good and bad drawings for typographic reproduction" by W. J. Baumgartner, University of Kansas.

12:00 Noon Meeting of Committees for 1939-'40, Ball Room of Union Building.
- Editorial Board, Committee on Conservation, Committee on Membership, Committee on Endowments.
- All other committees meet around tables in cafeteria.

1:30 p m. Sectional Meetings. (Botany, zoölogy, geology, psychology and junior academy, continued from morning.)
- Chemistry, Snow Hall, Room 206.
- Physics, Blake Hall, Room 210.
- Medical Science, Snow Hall, Room 502.

6:30 p. m. Senior Academy Banquet, Third Floor, Union Building.
- Dr. H. H. Hall, Toastmaster.
- Address of welcome, Chancellor E. H. Lindley.

6:30 p. m. Junior Academy Banquet, cafeteria.

8:00 p. m. Lecture by Dr. Laurence McKinley Gould, Professor of Geology, Carleton College, Northfield, Minn. "Exploration in the Antarctic," (with motion pictures). Hoch Auditorium.

SATURDAY, APRIL 1

8:00 a. m. General Session, Marvin Hall 206. Vice-president, E. O. Deere presiding.

Presidential address: Dr. Walter H. Schoewe, Professor of Geology, University of Kansas. "The Conservation of Our Natural Areas."

Main Academy Business Meeting, President W. H. Schoewe presiding.

1. Presentation of winning group and individual from the Junior Academy section.
2. Announcement of future selection of a Junior Academy boy and girl to be honorary junior members of the A. A. A. S.
3. Report of the Executive Council with recommendations.
4. Reports of all committees.
5. Geology of Monument Rock Area. George M. Robertson. Slides. 7 minutes.
   Flora of Monument Rock Area. Dr. F. W. Albertson. Slides. 7 minutes.
   Fauna of Monument Rock Area. L. D. Wooster. Slides. 7 minutes.
6. Reminiscences of Our Indian Service. Mrs. Otilla Reagan.
7. Collective Interference With Business and Labor. O. B. Holliday, Kansas City, Mo. By title.

10:00 a. m. Sectional Meetings.

Kansas Entomological Society, Snow Hall 417.

Biology Science Teachers, Snow Hall 101.

University Professors, Haworth Hall 101.

Geological Field Trip, 10:30 a. m. to 4:00 p. m.

Tours to places of interest about Lawrence for Junior Academy Members and others interested, at 10:30, arranged by the Lawrence Chamber of Commerce under the direction of J. M. Jewett.

Trip to paper mill.

Trip to organ factory.

12:30 p. m. 1939 Council Luncheon, North Alcove, Cafeteria.

1:30 p. m. Kansas Entomological Society, Snow Hall, Room 417.

Other sections may meet as scheduled in the forenoon.

Exihibts—Snow Hall, Room 220.

PAPERS SUBMITTED FOR THE SEVENTY-FIRST ANNUAL MEETING

BOTANY

Chairman: Clinton C. McDonald

Friday, March 31, 9:00 a. m. to 10:45 a. m., Snow Hall, Room 417

1. Kansas Flora: Nomenclatorial Items. F. C. Gates, K. S. C.
2. Kansas Botanical Notes, 1938. F. C. Gates, K. S. C.
3. Trends of Tree Migration in Kansas. F. C. Gates, K. S. C.
4. Winter Twigs: The Identification of Kansas Woody Plants by Their Twigs. F. C. Gates, K. S. C.
5. The Bearing of Zalenski's Law on Conifer Leaves. Lucile B. Burt, K. S. C.
6. Progress Report on Fruit Production With Nutrient Solutions. W. D. Durell, U. of K.
7. The Effect of 1-Ascorbic Acid (Vitamin C) on Botulinus Toxin. N. P. Sherwood, and Monte Belot, U. of K.
8. Cylindrosporium versus Septoria as the Causative Agent of Chrysanthemum Leaf-blight. J. A. Trent, K. S. T. C., Pittsburg.
9. Effects of Soil Amendments Upon Bacterial Populations Associated with Roots of Wheat. Francis E. Clark, K. S. C.
10. Rooting Ornamentals with Auxin. L. J. Gier and J. I. Memory. Campbell College, North Carolina.
11. An Often Overlooked Initial Stage in Secondary Plant Succession on Certain Badly Eroded and Burned Areas. W. E. Booth, U. of K.
12. An Anatomical Comparison of the Leaves of Four Species in the Genus Chamaesyce. Robert Lommasson, U. of K.
13. Variations in Systemic Infections of *Uromyces caladii*. Stewart M. Pady, Ottawa University.
14. Observations on *Coprinus micaceus* Growing in an Unusual Habitat. Stewart M. Pady, Ottawa University.

1:30 p. m.

15. Survey of the Fleshy Fungi of Crawford County, Kansas. Gerald Travis, Norton, Kan., and H. H. Hall, Pittsburg.
16. A Survey of the Flowering Plants of Crawford County State Park, Crawford County, Kansas. Ross Bennington, Iantha, Mo., and H. H. Hall, Pittsburg.
17. The Disappearance of a Society of *Camassia esculenta* Following the Burning-over of Its Prairie Meadow Habitat. W. C. Stevens, U. of K.
18. *Croton monanthogynus* and *Lespedeza striata* as Bank Covers. W. C. Stevens, U. of K.
19. Preliminary Survey of the Flora of Harvey County, Kansas. J. H. Doell, Bethel College.
20. *Taphrina osmundae* Nishida. A. J. Mix, U. of K.
21. Comparative Anatomical Study of Sun and Shade Species of Eupatorium and Ruellia. Florence E. Dill, U. of K.
22. Structure of the Embryo of *Setaria italica*. M. W. Mayberry, U. of K.
23. The Relation of Soil Fungi to *Ophiobolus graminis* Sacc. C. M. Slagg, K. S. C.
24. Ferns and Flowering Plants of Saline County. J. Hancin, Salina.
25. A Comparative Study of *Barterium proteus* and *Bacterium morgani*. Helen Hanson, U. of Wichita.
26. Studies of Native Cedars in West Central Kansas. F. W. Albertson, F. H. K. S. C.
27. Prairie Studies in West Central Kansas. F. W. Albertson. F. H. K. S. C.
28. A New Festuca for Kansas. John Webb, and F. W. Albertson, F. H. K. S. C.
29. A Study of the Variation in Growth of Blue Grama Grass from Seed Produced in Various Sections of the Great Plains Region. Andrew Riegel, F. H. K. S. C. By title.
30. Preliminary Report of Studies in Germinating and Breaking the Rest Periods of Seeds of Various Prairie Plants. Lester R. Branson, F. H. K. S. C.
31. *Allium perdulce*, a New Wild Onion in Kansas. S. V. Fraser, Aurora.
32. Botanical Notes, 1938. F. U. G. Agrelius, K. S. T. C., Emporia.
33. The Native Flora of Sedgwick County, Kansas. Sister M. Aquinas Stieferman, Wichita.

CHEMISTRY

Chairman: Fayette T. Owen

1:30 p.m. to 5:30 p.m., Friday, March 31, Snow Hall, Room 206

1. Two Beta-Arsenical Derivatives of Napthalene. Harold Brown, U. of K. C.
2. Surface Structure and Paint Adhesion Mechanism of Soft Woods. Allen L. Olson and Rex Toomey, K. S. C.
3. Animal Life in Synthetic Mixtures of Nitrogen and Oxygen with Different Percents of Relative Humidity. J. Willard Hershey and Charles Wagoner, McPherson College.
4. Electro Deposition of Some Metals from Solutions of Their Sulfamates. Harold S. Choguill, Independence Junior College.
5. Comparison of Phosphorus Solubility Curves with the Phosphorus Adsorption by Wheat. A. T. Perkins, W. H. Metzer, H. H. King, K. S. C. By title.
6. Thiazoles Obtained by Direct Thiocyanogenation. Ray Q. Brewster and Leland White, U. of K.
7. Studies of the Mechanism of the Königs-Knorr reaction for the Preparation of Glycosides, Preliminary Report. Leonard C. Kreider, Bethel College.
8. Effects of Organic Addition Agents Upon the Deposition of Zinc. Robert Taft and G. H. Senter, U. of K.
9. The Effectiveness of Iron Corrosion Inhibitors in Moving Acid Versus That in Still Acid. Lloyd McKinley, U. of Wichita.
10. The A B C's of the Achievements of Chemistry Since 1930. Lloyd McKinley, U. of Wichita.
11. Preparation of Mesidine and Some of Its Derivatives. Luther Lyon, Southwestern College.
12. The Lime Content of Rocks of the Upper Cretaceous System of Osborne County, Kansas. Herman Search and Roy Rankin, F. H. K. S. C.

GEOLOGY

Chairman: D. C. Schaffner

Friday, March 31, 9:00 a.m. to 10:45 a.m., Haworth Hall, Room 101

1. A Deposit of Mammal Bones Under Sleeping Bear Dune. David M. Gates, K. S. C.
2. The Genus Enteletes with Description of a New Species. Arthur Bridwell, Baldwin.
3. An Upper Silurian Vertebrate Fauna from the Middle Ludlow. George M. Robertson, F. H. K. S. C.
4. Some Structural Features of the Cherokee of Southeastern Kansas. G. E. Abernathy, Geological Survey of Kansas, Pittsburg.
5. Stratigraphy of the Central Valley of Darien Republic of Panama. John E. Embich, Cavalry School, Fort Riley, Kan.
6. A Working Hypothesis for the Evolution of Drainage in the Central High Plains. Harold T. U. Smith, U. of K.
7. Oil and Gas Seeps in Smith County, Kansas. Kenneth K. Landes, Geological Survey of Kansas and J. M. Jewett, U. of K.
8. The Geology and Ore Deposits of the Lost Lake Mining District, Boulder County, Colorado. Raymond E. Whitla, U. of K.
9. Shallow Aquifers in Eastern Kansas. J. M. Jewett, U. of K.

Afternoon session, 1:30 to 4:00 p.m.

10. The Bluff City Elephant. R. E. Mohler, McPherson, McPherson College.
11. Elephant Graveyard. D. C. Schaffner, C. of E.
12. The Use of Geology by the Kansas State Highway Commission. Roger L. Young, Jr., Geologist, Kansas State Highway Commission, Hoisington.
13. Evidence for the Relocation of West Drift Border in Eastern Kansas. W. H. Schoewe, U. of K.
14. Preliminary Report of Insoluble Residues of Missouri Series, Eastern Kansas. Grace C. Keroher, U. of K.
15. Progress in the Study of Fluorescence of Rocks and Minerals at the Institute of Sciences at Kansas City. B. Ashton Keith and J. Leland Jones, Institute of Sciences, Kansas City, Mo.
16. Relationship of Certain Recognized Lines of Crustal Weakness in Kansas to the Megashears—Giant Zones of Epigenetic Activity. B. Ashton Keith, Institute of Sciences, Kansas City, Mo.
17. The Continental Glaciers of the United States. Lyman C. Wooster, Emporia.
18. An Upper Silurian Vertebrate Fauna. George M. Robertson, F. H. K. S. C.

MEDICAL SCIENCE

Chairman: PARKE WOODARD

Friday, March 31, 1:30 p.m. to 5:00 p.m., Snow Hall, Room 502

1. The Collateral Circulation in the Hind Limb of the Cat. Tom G. Orr, Jr., and Homer B. Latimer, U. of K.
2. The Effects of Benzene on Leukocytes of Rabbits. Ira Collins, U. of K.
3. Blood Picture in the Rabbit Following Injection of Ergotamine Tartrate (Gynergen). Merrill J. Roller, U. of K.
4. Preliminary Report on the Effects of Sulfanilamide Feeding to Rats. Roy Beyer and L. L. Boughton, U. of K.
5. Notes on the Anatomy of the Foramen of Magendie. H. C. Tracy, U. of K.
6. The Effect of Growth and Maintenance of Weight of Life Cycle Feeding of Drugs to Albino Rats. L. L. Boughton and O. O. Stoland, U. of K.
7. The Effect of Insulin Shock on the Blood Picture in Rabbits. Harold Nelson, U. of K.
8. Some Electrocardiographic Changes Following Administration of Digiglucin. Wm. F. Blair and O. O. Stoland, U. of K.
9. Some Studies on Autolysis in Tissue Culture. Gerald Pees, U. of K.
10. The Growth of the Organs of the Urogenital System of the Cat. Homer B. Latimer, U. of K.
11. The Growth of Some of the Endocrine Organs of the Cat. Homer B. Latimer, U. of K.
12. An Application of Manometric Techniques to the Measurement of Bacterial Respiration. Randal Weed and Carl Petterson.

PHYSICS

Chairman: PENROSE S. ALBRIGHT

Friday, March 31, 1:30 p.m. to 5:30 p.m., Blake Hall, Room 210

1. The Magnifying Power of a Telescope for Objects at Close Range. R. F. Miller, C. of E.
2. The Solarized Latent Photographic Image. Anna Joyce Reardon, Mt. St. Scholastica College, Atchison.
3. A Recent Tour of European Laboratories. Lawrence W. Hartel, K. S. C.
4. An Easy Vector Method of Finding the Normal Spectroscopic Terms of the Elements. Alvin V. Pershing, Ottawa Univ.
5. Amateur Shop Technique. C. V. Kent, U. of K.
6. A Simple Accurate Method of Comparing Heat Conductivities of Metals. C. V. Kent, U. of K.
7. A One Reel Film on a Physics Subject from the Bureau of Visual Instruction. U. of K.
8. Distribution of Atomic Electrons from Electron Scattering Data. J. Howard McMillen, K. S. C.
9. The Role of the Dielectric Constant of an Addition Agent in a Plating Bath. Urea and Glycine in Gold, Platinum and Nickel Plating Baths. Arthur L. Stauffacher and Penrose S. Albright, Southwestern College, Winfield.
10. The Role of the Dielectric Constant of the Addition Agent in a Plating Bath. Amino Butyric Acid in Copper and Silver Plating Baths. Harlan E. Lenander and Penrose S. Albright. Southwestern College, Winfield.
11. Method of Preparing Electrets and Their Effect Upon Structure and Behavior. Wilfred M. Good, U. of K.
12. On the Optical Constants of Liquid Metals and Alloys. A. P. Friesen, Bethel College, North Newton.
13. The Use of Complex Numbers in Electrical Field Mapping. Richard J. W. Koopman, U. of K.
14. High-school Experiments With Polarized Light and Wind Resistance. Otis White. Dexter High School, Dexter.
15. A Determination of the Dielectric Constant of Water. T. D. Morgan and Penrose S. Albright, Southwestern College, Winfield.

PSYCHOLOGY

Chairman: JOSEPH W. NAGGE

Friday, March 31, 9:00 a.m. to 10:45 a.m., Frank Strong Hall, Room 9

1. An Evaluation of Beck's Norms as Applied to Young Children. Harriet Dunmire, Wichita Child Guidance Center.
2. A Study of Personality and Its Relation to Intelligence, Home and Family Influences, School Activities, and Scholastic Achievements. H. E. Schrammel, K. S. T. C., Emporia.

3. A study of Children Exhibiting Pattern Loss During Performance of a Mental Test. Edwina A. Cowan, Wichita Child Guidance Center at Friends Univ.
4. The Knowledge of the Scientific Method Among College Students. Arthur John Ter Keurst and Robert E. Bugbee, C. of E.
5. Centripetal Drift of Scores in Two Adjacent five-minute Periods of a Mental Test. J. C. Peterson, K. S. C.
6. A Preliminary Report on the Levy Sibling Technique as Used with Children at the Wichita Child Guidance Center. Edra M. Weathers. Friends Univ.

1:30 p. m. to 5:00 p. m.

7. Skin Conductance Changes Occurring During Mental Fatigue. Edward W. Geldreich, K. S. T. C., Emporia.
8. Warm and Cold Climate Art. Raymond H. Wheeler, U. of K.
9. A Laterality Experiment. W. H. Mikesell and Martin Palmer, U. of Wichita.
10. A Correlation of Certain Attitudes with Personality Traits. J. A. Glaze, K. S. T. C., Pittsburg.
11. The Cowan Delinquency Index. Robert L. Brigden, Wichita Child Guidance Center.
12. A Comparison of Two Methods of Teaching Introductory Psychology. Paul Murphy, K. S. T. C., Pittsburg.
13. Brain Minerals and Learning Ability in White Rats. O. W. Alm, K. S. C.
14. Psychological Problems Involved in the Private Employment of Nonschool NYA Young People in Ellis County. Floyd E. Reynolds, F. H. K. S. C.
15. An Experimental Study of Attitudes Toward the Public School. Howard Siple, K. S. T. C., Pittsburg.

SCIENCE TEACHERS—BIOLOGY

Chairman: Lorene Bailey. Acting chairman: Gladys Beck.

Saturday, April 1, 10:00 a. m. to 12:15, Snow Hall, Room 101.

1. High School and College Biology. John Breukelman, K. S. T. C., Emporia.
2. Course and Credit Trends in the Biological Sciences in High Schools as Evidenced by a Study of 2,237 Transcripts of High-school Graduates. J. Ralph Wells and Olive J. Faulkner, K. S. T. C., Pittsburg.
3. How to Conduct Project Work in Biology. Claude H. Huffman, Pittsburg High School.
4. Health Program in the Arkansas City High School. Charles E. Ruff, Junior College, Arkansas City.
5. How Can I Make My Teaching More Scientific? Dewey Bennett, Junior College, Garden City.
6. A Comparative and Comprehensive Study of Eight High-school Biology Textbooks. Don Gooden, Mound City, or H. H. Hall, Pittsburg.
7. New Methods of Teaching Biology in High School. W. L. Hoyle, Arkansas City.

ZOÖLOGY

Chairman: E. H. Herrick

Friday, March 31, 9:00 a. m. to 10:45 a. m., Snow Hall, Room 101.

1. The Identification of Burrowing Insects by Their Burrow Characteristics. H. R. Bryson, K. S. C.
2. A Collection of Kansas Fishes in the State University Museum. John Breukelman, K. S. T. C., Emporia.
3. The Distribution of the Genus *Peromyscus* in Kansas. J. M. Sprague, U. of K.
4. A Preliminary Study of the Baculum of *Peromyscus leucopus* and *P. maniculatus* in Kansas. J. M. Sprague, U. of K.
5. A Study of the Reptiles, Amphibians and Mammals of Meade County, Kansas State Park. J. A. Tihen and J. M. Sprague, U. of K.
6. A Study in Jack Rabbit Shifts in Range in Kestern Kansas. F. L. Carter, Wilson High School, Wilson.
7. The Eighth Annual Insect Population Summary of Kansas—1938. Roger C. Smith and E. G. Kelly, K. S. C.
8. Additional Notes on the Mammalian Fauna of Edson Quarry, Middle Pliocene of Sherman County, Kansas. Claude W. Hibbard, U. of K.
9. Notes on Some Mammals from the Pleistocene of Kansas. Claude W. Hibbard, U. of K.
10. An Ecological Evaluation of Predatees on a Mixed Prairie Area in Western Kansas. L. D. Wooster, F. H. K. S. C.
11. Variation in the Snake *Thamnophis macrostemma*. Malcom J. Brumwell, U. of K.

1:30 p. m. to 4:00 p. m.

12. The Use of a Home-made Mirror Telescope for Bird Study. R. F. Miller, C. of E.
13. Genetic Aspects of Pigment Production in the Guinea Pig. Mary T. Harman and Annette Alsop. K. S. C.
14. Cytological Aspects of Pigment Production in the Guinea Pig. Mary T. Harman and Annette Alsop. K. S. C.
15. Some Effects on Guinea Pigs of Feeding Vitamin C Intermittently. Mary T. Harman and Abbie Miller, K. S. C.
16. Studies in Human Biology. E. H. Herrick, K. S. C.
17. Cytological Changes in the Pituitaries of Castrate and Adrenalectomized Male Fowls. John C. Finerty and E. H. Herrick, K. S. C.
18. Injection of *Corpora lutea* Extract in Pregnant Guinea Pigs on a Vitamin C Limited Diet. Olga B. Saffry and John C. Finerty, K. S. C.
19. On the Anatomy of a Two-faced Kitten. S. L. Loewen and Roy M. Kash, Sterling College, Sterling.
20. A Polydactylous Lizard. S. L. Loewen. Sterling College.
21. An Unusual Anomaly of the Postcava in the Thoracic Region of the Cat. Donald J. Ameel, K. S. C.
22. Tertiary Butyl Alcohol as a Dehydrating Agent in Making Microscopic Mounts of Insect Material. J. B. Tuck, K. S. C.
23. A Study of the Structure of Hair as a Means of Mammal Identification. Earl R. Oyer, Supt. Schools, Long Island.
24. Movement in Transforming Spermatids in Insects. W. J. Baumgartner, U. of K. By title.
25. Notes on Type Specimens and Description of North American Bombyliidae. R. H. Painter, K. S. C. By title.
26. New Blind Snakes from Central America and Peru. Edward H. Taylor, U. of K. By title.
27. New Species of Mexican Salamanders. Edward H. Taylor, U. of K. By title.
28. Mexican Herpetological Novelties. Edward H. Taylor, U. of K. By title.
29. The Effect of Successive Drought Years on the Chloropid (Diptera) Populations in Grasslands in Kansas. Donald A. Wilbur and Curtis Sabrosky, K. S. C. By title.
30. The Effect of Successive Drought Years on the Grasshopper Population in Grasslands in Kansas. Donald A. Wilbur and Roy Fritz, K. S. C. By title.
31. The Comparative Susceptibility of the Confused Flour Beetle (*Tribolium confusum* Duv.) and the Rust-red Flour Beetle (*T. castaneum,* Hbst) to Three Fumigants. Roy F. Fritz, K. S. C. By title.
32. Intermediate Hosts of Chicken Tapeworms Occurring in Kansas. A. A. Case and J. E. Ackert, K. S. C.
33. Further Studies on Goblet Cells and Age Resistance to Parasitism. S. A. Edgar and J. E. Ackert, K. S. C.
34. Studies on Culturing Nematodes *in Vitro.* J. E. Ackert and L. P. Frick, K. S. C.
35. Nerve Action in the Stalk of Vorticella. E. J. Petry, Institute of Sciences at Kansas City, Mo.
36. An Improved Technic in the Isolation of the Chromosomes from the Salivary Glands of the Larvae of *Drosophila melanogaster.* Eugene C. Roberts. (Introduced by H. H. Hall.)
37. Excavation of a Runway of the Pocket Gopher (*Geomys bursarius*). T. H. Scheffer, U. S. Biol. Survey.

KANSAS JUNIOR ACADEMY OF SCIENCE

President: Bill Akey, Pittsburg High School.
Secretary: Dorothy Brownlee, Wichita High School, East.

(For program see Report of the Junior Academy Committee, a few pages following.)

KANSAS ENTOMOLOGICAL SOCIETY

Fifteenth Annual Meeting

L. C. Woodruff, President; R. T. Cotton, Vice-president;
H. H. Walkden, Secretary-Treasurer

Saturday, April 1, Business Meeting, 10:00-11:00 a. m., Snow Hall, Room 417

1. Studies of Some Physical Factors Affecting the Resistance of Wheat to Hessian Fly Attack. Elmer T. Jones, Bur. Ent. and Pl. Quar. Manhattan.
2. Some Studies on the Nesting Habits of *Batazonus navus Cresson.* Robert E. Bugbee, C. of E.

3. The Identification of the Eggs of Grasshoppers by the Sculpturing of the Chorion. J. B. Tuck, K. S. C.
4. Some Additional Grasshopper Collection Records. Roland W. Portman, K. S. C.
5. Recent Notes on the Activities of Beetles of *Phyllophaga lanceolata* (Scarabaeidae). H. R. Bryson, K. S. C.
6. Road Crickets. R. H. Beamer, U. of K.
7. A Question of Synonymy. H. B. Hungerford, U. of K.
8. Labels and Labeling Insects. R. H. Painter, K. S. C.

Presentation of Papers, 1:30 p. m., Snow Hall, Room 417

9. Observations on Subterranean Termites Attacking Living Plants. F. L. McDonald, K. S. C.
10. Notes on the Rapid Plant Bug (*Adelphocoris rapidus* Say) as An Economic Pest. Chas. Curtiss, K. S. C.
11. Preliminary observation of *Crambus* in Kansas. H. D. O. Miller, K. S. C.
12. Effects of High Soil and Air Temperatures on Some Alfalfa Insects. Roger C. Smith, K. S. C.
13. A Method of Utilizing Pyrethrum for Greenhouse Fumigation. R. H. Beatie. U. of K.
14. A Consideration of the White-fringed Beetle as a Potential Pest in Kansas. L. S. Henderson, U. of K.
15. Observations on Ozark Cave Beetles. M. W. Sanderson, U. of Ark.
16. The Biology of the Black Blister Beetle (*Epicauta pennsylvanica Deg.* Meloidae, Coleoptera). Wm. R. Horsfall, U. of Ark.
17. A Revisional Study of New World *Plecia* and *Penthetria* (Bibionidae Dipteria) D. Elmo Hardy, U. of K.
18. Factors Influencing Extra Molts in the Roach. Max Temple, U. of K.
19. The Genus *Aligia* (Cicadellidae, Homoptera). L. W. Hepner, U. of K.
20. The Systematic Value of Genitalia in the Genus *Ormenis* (Fulgoridae, Homoptera). Chas. L. Shepard, U. of K.
21. A New Pest of Junipers. Edw. G. Wegenek, U. of K.
22. Rhopalocera, Distributional Notes for Southwestern United States. Wm. D. Field, U. of K.
23. Notes on the Distribution of the Genus *Trichocorixa*. R. I. Sailer, U. of K.
24. Insect Notes on the Hickory Borer and Redbud Aphid. R. L. Parker, Experiment station, Manhattan.
25. Folklore of Poisonous Arthropods of Mexico. L. J. Lipovsky, U. of K.
26. Final Report on the Mosquitoes of Kansas. Mrs. Noblesse De Moss Hill. By title.
27. Adjusting Insect Control Practices to the Soil Conservation Program. Don B. Whelan, U. of Nebraska, Lincoln.
28. The Role of Plastics in the Field of Entomology. Don B. Whelan, U. of Nebraska, Lincoln.

KANSAS CHAPTERS, AMERICAN ASSOCIATION OF UNIVERSITY PROFESSORS

Dr. D. A. Worcester, University of Nebraska, Regional Representative

Saturday, April 1, 10:00 a. m. to 12:00 noon, Haworth Hall, Room 101

1. Some Desirable Features in the Set-up of a Faculty Organization. Dr. J. E. Hollingsworth, Washburn College, Topeka.
2. An Active Policy for the American Association of University Professors in Kansas? Dr. William T. Paullin, U. of K. Discussion.
3. Democracy the One Safeguard of Intellectual Freedom. Professor C. E. Rogers, K. S. C. Discussion.
4. Business meeting.

Luncheon 12:30, Pine Room, Union Building

1. The Association and the Teaching Profession. Dr. D. A. Worcester, U. of Nebraska.
2. The Place and Functions of Faculties in College and University Governments. Dr. Ernest M. Anderson, K. S. T. C., Pittsburg.

Members of the Kansas Academy of Science, and the faculty of the University of Kansas are cordially invited to attend the meetings of the American Association of University Professors.

MINUTES AND REPORT OF THE SEVENTY-FIRST ANNUAL MEETING, HELD AT LAWRENCE

The seventy-first annual meeting of the Kansas Academy of Science which was held at Lawrence, Kan., March 30, 31, and April 1, 1939, was called to order at 7:45 p.m. by President W. H. Schoewe, in the auditorium of Frank Strong Hall, to hear a lecture by Dr. Charles A. Shull, of the University of Chicago. His subject was "The Plant in Relationship to the Water System of Its Environment." This lecture was sponsored by the Kansas chapters of Phi Sigma and Sigma Xi and the Kansas Academy of Science. Following the lecture, which was attended by 250 persons, a general reception was held for all members and visitors at the Union building.

The executive council met before this lecture, however, and was in session from 2:45 to 5:30 p.m. This meeeting was attended by Messrs. Schoewe, Hall, Deere, Smith, Zinszer, Gates, Baumgartner and Wheeler. Professors Dean and Oncley were absent. The following business was transacted:

1. All reports printed in the program were discussed and formally adopted.

2. It was decided that $42.50 be granted from the Academy treasury for use of the committeee on awards, which provides $75 from the A. A. A. S., $42.50 from the Academy, and $32.50 from the Albert B. Reagan endowment, or a total of $150 for awards. The sum of $42.50 was approximately equal to the earnings from the endowment for the year.

3. It was decided that a maximum of $60 would be allowed by the Academy for transportation expenses for representation at the Academy conference during the holiday meeeting of A. A. A. S. at Columbus, Ohio. The division of funds and the selection of representatives were left to the new executive committee.

4. The council discussed the advantages and disadvantages of operating on a budget plan. It was decided to continue on the same basis as in the past, without a budget, because of the difficulties of preparing a satisfactory annual budget and because the past method has been satisfactory.

5. It was decided that funds for the expense of committees in carrying on their work should be requested of the executive committee in writing, giving the proposed needs and expenditures, and that sums would not be set aside other than on requests.

6. Since the constitution is not clear as to whether the decisions and interpretations of the executive council had to be approved by the Academy at a business meeting before they were official and binding, the council decided that all matters of routine need not be so approved, but that all matters involving policies or fundamental changes should be taken before the general meeting for discussion and voting. It was further agreed that the secretary's report should record all decisions, so that all members may be fully informed of these actions and that they should become a part of the printed record. The Academy may question, challenge and overrule any decision of the executive council at the general sessions.

7. It was agreed that the application of the Weather-Crops Seminar for affiliation with the Academy as a section, on the same basis as the affiliation of the Kansas Entomological Society, be approved.

8. The Committee on Coördination of Scientific groups was instructed to draw up a definition of "affiliation" and to outline the steps by which groups may affiliate with the Academy. They were further charged to investigate other state Academies and bring to next year's meeting of the executive council recommendations on how far the Academy should go in accepting affiliating groups. This applies particularly to the humanities and subjects not usually classified as sciences.

9. It was decided to accept the invitation of Wichita and hold the 72d annual meeting there in 1940, and the 73d at Manhattan in 1941.

10. It was recommended that the $375 U. S. treasury savings bond be transferred from the checking account to the endowment fund.

11. The incoming president, H. H. Hall, and the outgoing president were instructed to constitute a committee to begin preparations for the 75th anniversary of the Academy in 1943.

12. The proposed amendments (see Transactions 41:32:1938) were discussed and it was agreed that the council recommend to the Academy that they be accepted.

The first general business session was held at 11 a.m. Friday, March 31, in Marvin Hall, President Schoewe presiding. Some substitutions for absent members of committees were announced. An interesting innovation in the program was one-minute reports of the recipients of the 1938 research awards. This was followed by reports of officers, delegates to meetings, a short report by the managing editor, W. J. Baumgartner, on good and bad drawings in papers for publication in the TRANSACTIONS, and a lantern slide demonstration lecture on color photography, by Oren Bingham. The slides were truly remarkable in their beauty, range of subjects and color values.

The second business and general session was held Saturday at 8 a.m. President Schoewe gave the annual presidential address on "The Conservation of our Natural Areas." This is a subject in which Doctor Schoewe is greatly interested and is unusually well fitted to discuss. He stressed the difficulties which have arisen to making areas into national parks or national monuments and maintaining them as such. This address was followed by a report of the judges on the Junior Academy meeting, announcement and awarding by President Schoewe of prizes and ribbons to groups and individuals, and the reports of all committees. These reports, which were all adopted, are published in subsequent pages.

Mrs. Otilla Reagan, who so graciously set up the Albert B. Reagan Endowment in the Academy in memory of her distinguished husband, attended the Academy sessions and spoke, following the business meeting, on "Reminiscences of Our Indian Service" She recounted many interesting experiences and observations during their long period of work on Indian reservations. She made the statement that it was her wish that the income from the Reagan Endowment should go by preference to the young struggling scientist who in some cases, is having nearly as difficult time getting research done and published as did Doctor Reagan. The committee on awards and the Academy as a whole are in complete sympathy with this desire and will attempt to carry it out fully.

A series of lantern slides on the Monument Rock Area were shown as a part of the report on natural areas. George M. Robertson reported on the geology, F. W. Albertson on the flora, and L. D. Wooster reported on the

fauna of this area, which it is hoped to have designated some day as a state monument.

The Academy met in sections, the reports of which are presented in tabular form, as follows:

Name of Section.	Chairman, 1939.	Attendance.	Number of papers.	Officers for 1940.
1. Botany	C. C. McDonald	75	33	M. W. Mayberry
2. Chemistry	F. T. Owen	60	12	Harold P. Brown
3. Geology	D. C. Schaffner	50	18	Albert C. Carpenter.
4. Medical Science	Parke Woodard	60	12	None
5. Physics	P. S. Albright	80	15	A. B. Cardwell
6. Psychology	Jos. W. Nagge	63	15	W. H. Mikesell
7. Biology teachers	Lorene Bailey and Gladys Beck, chairman pro tem.	40	7	John Breukelman
8. Zoölogy	E. H. Herrick	60	37	A. B. Leonard
9. Kansas Entomological Society.	L. C. Woodruff	55	28	R. T. Cotton
10. Junior Academy of Science.	Bob Akey, president	250	12	Gabe Sellers, Jr., Pres. Kenneth Hunt, Secy'.

The Kansas and Nebraska chapters of the American Association of University Professors again met in coöperation with the Academy, under the chairmanship of Dr. D. A. Worcester. The attendance was 65, and there were four main addresses given. Prof. Robert Conover was elected chairman for 1940.

On Friday evening the regular annual banquet was held in the ballroom of the Union building. There were approximately 250 present. Dr. H. H. Hall was toastmaster, and during the banquet introduced some of the older members present, and former presidents of the Academy. Chancellor E. H. Lindley, of the University, gave an appropriate short address of welcome, emphasizing that science and scientists are less presumptious than formerly and that they now have their logical and important place in institutions of higher learning, along with arts, literature, and the humanities.

After the banquet the members went to Hoch Auditorium to hear an unusually inspiring and interesting lecture by Dr. Laurence McKinley Gould on "Explorations in the Antarctic." There were approximately 2,500 people present to enjoy the wit of the speaker, and the interesting and informative address. An informal reception for Doctor Gould was held in the Union building following the lecture.

Following the program of the Kansas Entomological Society, the ladies of the University staff of the Department of Entomology served tea in the departmental offices, which permitted a general getting acquainted.

The meeting was outstanding because of the excellence of the two evening speakers, Doctors Shull and Gould; because of the splendid arrangements made by the committee under the leadership of Dr. R. H. Wheeler; because every program was full, but not too full, and the papers were of unusual interest and merit, and lastly, because of the remarkable program and growth of the

Junior Academy of Science. Three hundred and thirty-five persons registered for the meeting, which is the largest attendance ever recorded for an annual meeting. There were 200 new members joined the Academy during the year. This is the largest number of new members for any year.

The 1939-1940 executive council met at noon Saturday. The following business was transacted:

1. The Council voted to delegate the president, H. H. Hall, to apply for some of the fund recently made available for advertising Kansas. The Academy could use such funds to call attention of the public to the wild life of the state, vegetation and unusual geological features.

2. Dr. R. C. Smith was designated as the Academy representative to the Columbus meeting of the A. A. A. S., with Dr. W. J. Baumgartner as alternate, and both sharing equally in the fund of $60 voted for the purpose.

Numerous other matters were discussed, but no action was taken.

April 3, 1939. ROGER C. SMITH, *Secretary*.

REPORT OF SECRETARY APRIL 1, 1938, TO APRIL 10, 1939

The minutes and report of the seventieth annual meeting at Pittsburg were prepared and are published in volume 41 of the TRANSACTIONS, pages 31-49. The report for "Science" was published in volume 88:(2277) 168-169. On April 29, 2,500 envelopes, 2,800 letterheads, and 1,300 dues cards were ordered at a cost of $30.60; 1,000 copies of an 8-page pamphlet giving the personnel of committee appointed by President Schoewe and objectives of each committee were printed at a cost of $20 and were distributed with the copies of volume 40 to the membership on June 15. This pamphlet served as a notification of appointment to committees. It was republished in volume 41, on pages 50-58.

The $75 from the A. A. A. S. was received on April 26, immediately on report to the Association of the recipients of the research grants. The funds were made available to the grantees upon request.

The entire cost of the Pittsburg meeting to the Academy was only $9.90, the larger portion of the incidental expenses being borne by the Kansas State Teachers College.

A special meeting of the editorial board was called at Manhattan on May 14 to decide some matters of editorial policy and procedure, the cost of $19.39 being paid by the Academy.

The treasurer, Doctor Zinszer, was reported to the A. A. A. S. as the Academy representative for the holiday conference and Doctor Schoewe's report on academies was recommended to the secretary of the Academy Conference as highly appropriate for a program feature, which recommendation was accepted. The Academy was represented at the Richmond meeting by these two officers and Miss Edith Beach.

The secretary ordered the following supplies: 500 notices, with return, for requests for copies of the TRANSACTIONS at $5; 500 membership cards, $3; a substantial typewriter stand, $6; envelopes and stamps, $5.

With the $300 state appropriation to the Academy, $215.83 was spent for cuts for volume 41, leaving a balance of $84.17 for stamps, which were purchased September 27. Statements for exchange rights were mailed to the three coöperating libraries on December 12.

One thousand eight-page preliminary announcements of the Lawrence meet-

ing were printed during the close of the year at a cost of $21 and mailed with dues notices to members for 1939, on January 6, 1939.

Four lists of new member nominations were placed before the membership committee and all nominees were elected. Letters notifying new members of their election, and membership cards, were mailed to the new members. Lists of "lost members" and of those delinquent in dues for 1938 and in danger of being dropped from the rolls were prepared and mailed to the entire membership committee and to academy officers. Five hundred seventy-five envelopes were addressed for President Schoewe in which appropriate Christmas greetings were sent to the membership at his expense on December 17.

Delivery of volume 41 was made by the state printer November 23, and the volumes were distributed to the coöperating libraries and the reprints and volumes to the membership paid up for 1938 during the next few days. The cost of printing and binding of volume 41 to the state was $2,379.96. This, with the $300 appropriation, $75 from the A. A. A. S., $500 from exchange rights, provides a total of $3,254.96, or on the basis of 600 paid up members, about $5.42 per member, which the member receives for $1 dues.

Dr. W. H. Schoewe made a sufficient advance payment to total thirty dollars and is therefore eligible, according to section 3, article 2 of the constitution, to be made a life member.

The research allotment from the A. A. A. S. for 1939 is $75, according to word received January 20.

A summary of the membership is as follows:

	April 15, 1938	*April 10, 1939*	*Increase or decrease*
Honorary members	8	7	— 1
Life members	48	41	— 7
Annual members paid for 1938	134	('39) 278	+144
Annual members paid for 1937	154	('38) 133	— 21
Annual members paid for 1936	79	('37) 78	— 1
Junior Academy Clubs	17	28	+ 11
Institutions and libraries	7	8	+ 1
New members	178	113	— 65
Total members on mailing list	625	686	+ 61
Gains in membership:			
Reinstatements	2	6	+ 4
New members (including Junior Academy Clubs and institutions)	189	125	— 64
Total gains	191	131	— 60

Losses in membership:

	April 10, 1939
Dropped for nonpayment of dues	78
Resignations	9
Deaths	10
Total losses	97
Transfers from annual to life membership	1

One thousand five hundred copies of the program for the Lawrence meeting were prepared and mailed to the entire membership about March 20, 1939.

Miss Frances Cole, an N. Y. A. appointee, served most acceptably as office assistant to the secretary during the school months.

Deaths of the following members were reported to the secretary during the year: A. E. Aldous, Rev. John T. Copley, Lloyd Shaffer, E. A. White, C. L. Harris, Lumina C. R. Smyth, John H. Schaffner, Edward L. Nichols, F. W. Bushong, and Charles M. Sterling.

Dr. W. A. Dill, of the University of Kansas, appointed by President

Schoewe as publicity director for the year, died early in 1939. While not a member of the Academy, his passing is noted with much regret because of his apparent friendliness to this organization.

H. D. Young, S. A. Summerland, F. L. Duley, E. Louise Gibson, Newell E. Good, Pittsburg S. O. S. Science Club, and W. E. Matter resigned while in good standing, and Mrs. Clayton Baldwin (nee Carol Bardo) resigned January 19, owing dues for 1938.

The Academy appears to be flourishing. The work of the officers has been done with noteworthy thoroughness and promptness.

ROGER C. SMITH, *Secretary.*

REPORT OF THE MEMBERSHIP COMMITTEE

The following new members were accepted by the membership committee between April 20, 1938, and April 14, 1939:

Agra: Abbie Miller.
Atchison: Science Club, Fred H. Fiss.
Ayden, N. C.: Edgar M. Leonard.
Belleville: Glenn B. Snapp.
Bronxville, N. Y.: Mary Jane Reid.
Burlingame: Burlingame Biology Club, Dolf J. Jennings.
Burlington: Burlington H. S. Science Club.
Caldwell: Science Club.
Champaign, Ill.: Clyde T. McCormick.
Colby: Colby H. S. Science Club.
Concordia: John M. Porter.
Delaware, Okla.: Ruth Jarboe.
Dexter: Otis White.
Emporia: Edward W. Geldreich, Arthur J. Ter Keurst, James Eubanks, Warne D. Keller, Ted Downs, Raymond Johnson, R. Norris Miller.
Fairfax, Okla.: Paul McGuire.
Girard: Science Club, W. V. McFerrin.
Hanover: George B. Scott.
Hays: Geo. McAfee Robertson, Lester J. Schmutz, Melvin D. Smith, Andrew Riegel, Frank Osborne, Cecil L. Hase, Lawrence Cressler, Arthur A. Cooper, Charles W. Cook, Hugh Agnew, Claude W. Bire, John Webb, Jack Eades, Dean R. Isaacs, Marvin Lacey, Maurice Lawson, Floyd Reynolds.
Hill City: Hill City Memorial H. S. Science Club.
Hillsboro: Paul K. Weimer.
Imogene, Iowa: Lucille Laughlin.
Independence: Dalton Simons, Jr.
Jonesboro, Ark.: Sister M. Agnes Voth.
Kansas City, Kan.: Argentine Biological Science Club of Kansas City.
Kansas City, Mo.: Bernice Hale, C. B. Holliday, B. Ashton Keith, J. Leland Jones.
Lawrence: G. Baley Price, Wm. K. MacFarquhar, Roger L. Young, Tom G. Orr, N. W. Storer, William R. Taylor, W. E. Booth, Earnest Boyce, Seville Chapman, Kathleen C. Doering, Norman Ginsberg, A. B. Leonard, Gerald B. Pees, O. O. Stoland, Geo. W. Stratton, Lalia V. Walling, Clifford L. Willis, Parke Woodard, Lawrence C. Woodruff, Clinton M. Young, Malcolm J. Brumwell, Oread Science Club, Leland White, Roy R. Beyer.
Lindsborg: John Ericson.
Long Island: Earl R. Oyer.
Madison: Madison H. S. Science Department.
Manhattan: R. L. Parker, W. H. Riddell, Fred L. Parrish, W. T. Stratton, Anna Marie Sturmer, Robert G. Chapman, Frederick L. McDonald, H. D. Oliver Miller, W. H. Metzger, Lee S. Fent, Clarence W. Rice, C. M. Slagg, Lee M. Roderick, Francis E. Clark, Elizabeth McCracken, Lyman P. Frick, David M. Gates, R. W. Conover.
McPherson: Paul E. Prathen.
Merriam: Retorts Science Club.
North Newton: Leonard C. Kreider, Robert L. Schmidt, Glenn V. Becker.
Norton: Science Club.
Osawatomie: Delma Branson.
Osborne: Herman Search.
Ottawa: John J. Pinney, A. V. Pershing.
Pittsburg, Kan.: Gerald V. Griffith, Lucile Hall.
Pittsburgh, Pa.: Sister Angelica, Howard L. Siple.
Pratt: Elmo W. Huffman.
Stockton: John Earl Butler.
Sterling: Roy M. Kash.
Salina: Sister Ann Cesile Bauer.
Stafford: Science Club, Alex Richards.
Topeka: Seaman Science Club.
Washington, D. C.: Charles F. Sarle, C. W. Thornthwaite.
Wichita: Harriett Dunmire, Helen Hanson, Earl Abbott.
Wilson: F. L. Carter.

Total, 125.

ROGER C. SMITH, *Chairman,*
F. W. ALBERTSON,
FRANK U. G. AGRELIUS,
EDITH BEACH,
PAUL MURPHY,
Committee on Membership.

TREASURER'S REPORT

MARCH 31, 1938, TO MARCH 30, 1939

RECEIPTS

Balance in checking account, March 31, 1938		$216.23
Dues from members		486.00
Sale of transactions		9.65
Exchange rights:		
K. S. C., volume 40	$200.00	
K. U., volume 40	200.00	
K. U., volume 41	200.00	
Fort Hays, volume 41	100.00	
		700.00
Interest on endowment fund		78.83
A. A. A. S. award		75.00
Principal and interest, postal savings certificates		514.50
Appropriation by legislature		300.00
Total		$2,380.21

DISBURSEMENTS

Awards:		
John Breukelman (Reagan)	$32.50	
Harry Bryson (A. A. A. S.)	25.00	
Roger Smith (A. A. A. S.)	25.00	
Edwina Cowan (A. A. A. S.)	25.00	
Edwina Cowan (Academy)	15.00	
Frank Gates (Academy)	42.50	
Mary Harmon (Academy)	42.50	
		$207.50
Junior Academy		67.57
Committee on education trends		22.11
Kansas geological survey		1.77
Editorial board meeting, Manhattan		19.39
Pittsburg meeting, expenses		34.70
Secretary—help, supplies, stamps, express		213.78
Treasurer—bond, lockbox, stamps, registering		17.68
Managing editor—expressage, trips, Topeka		29.06
Editor-in-chief—preparing material		1.80
President's report		2.60
Capper Engraving, cuts		176.98
Peterman Engraving, cuts		38.85
Kimball Printing, printing		134.60
U. S. savings bond D395746C		375.00
Postal savings certificates		900.00
Treasurer to Richmond, A. A. A. S.		65.80
President to Richmond, A. A. A. S. (one way)		23.60
Balance in checking account		47.47
Total		$2,380.21

Supplementary statement:		
Bank balance	$126.83	
Postal savings certificates	800.00	
U. S. savings bond D395746C	375.00	
		$1,301.83
Uncanceled checks	$79.36	
Payable to endowment fund	81.37	
		160.73
Net balance		$1,141.10

Respectfully submitted,
HARVEY A. ZINSZER, *Treasurer.*

REPORT OF ENDOWMENT COMMITTEE

RECEIPTS

Balance in general fund	$2.54
Cash earnings during 1938	78.83
Total	$81.37

There being no disbursements during the year, there still remains in the general fund a net balance of $81.37.

INVESTMENTS

4 shares (620 to 623) Morris Plan, Wichita, 5 percent	$400.00
5 shares (OS-1181) First Federal Savings and Loan of Kansas City, $94.53 at 4 percent; certificate No. 1269, Western Shares, $205.47	300.00
1½ shares (2898 full-paid) Greene County Building and Loan, 4 percent	150.00
1½ shares (2679 class B) Greene County Building and Loan	150.00
1 No. 78366F $1,000 U. S. bond 1938-'44 at 3¼ percent	1,000.00
1 No. 46567H $500 U. S. bond 1955-'60 at 2⅞ percent	500.00
1 No. 88419K $100 U. S. bond 1955-'60 at 2⅞ percent	100.00
1 No. 11359K $100 U. S. bond 1951-'55 at 3 percent	100.00
1 No. 670L $50 U. S. bond 1951-'55 at 3 percent	50.00
1 (L235510) $50 U. S. savings bond 1945	37.50
1 (C260992) $100 U. S. savings bond 1945	75.00
1 (D84554) $500 U. S. savings bond 1945	375.00
1 (C446471) $100 U. S. savings bond 1945	75.00
1 (C446471) $100 U. S. savings bond 1945	75.00
1 (D138039B) $500 U. S. savings bond 1946	375.00
1 (C492889B) $100 U. S. savings bond 1946	75.00
1 (C492890B) $100 U. S. savings bond 1946	75.00
1 (C492891B) $100 U. S. savings bond 1946	75.00
In general fund	81.37
Total	$4,068.87

The earnings situation with the Greene county and the First Federal Savings is unchanged from that of last year, while the earnings of the Morris Plan has diminished from 5 to 3.7 percent. All evaluations above are based on purchased, not the accrued value.

Respectfully submitted,

GRIMES, CALL, DEAN, PITTMAN, NABOURS, ZINSZER.

REPORT OF THE AUDITING COMMITTEE

March 31, 1939

The President, the Kansas Academy of Science:

The treasurer's books have been audited as of this date and found to be correct.

THE AUDITING COMMITTEE,
ALVIN V. PERSHING, *Chairman.*
ERIC R. LYON.

REPORT OF THE DELEGATE TO THE ACADEMY CONFERENCE, RICHMOND, VIRGINIA

Y. M. C. A., December 28, 1938

The Academy Conference, which has as its object the promotion of cooperation among the affiliated academies, and between them and the Association, lasted throughout the afternoon of the 27th and right through the banquet hour, so interesting were the topics under discussion.

The principal discussions, guided skillfully by the officers of the executive council, were (1) The Proper Distribution by the Academy and an Adequate Response on the Part of the Recipient of the A. A. A. S. Award, and, (2)

The Relation of the American Institute of the City of New York to the Junior Academy Movement. The former organization, with its large financial resources, are sponsoring a nationwide science club movement which caused no little concern among the representatives at the Conference.

Seventeen state academies were represented at the Conference, including the American Institute. Among the papers read were: "A Comparison of the State Academies Affiliated with the A. A. A. S.," by Dr. W. H. Schoewe; and "The Objectives of the Academy Conference," by Dr. Bert Cunningham, chairman of the Conference. Later, a symposium on "Financing Academy Publications," was led by representatives of the following academies: Illinois, Indiana, Iowa, Kansas, North Carolina and West Virginia. In addition to your treasurer, Dr. W. H. Schoewe, Dr. W. J. Baumgartner and Dr. Elvira Weeks were also in attendance at the Conference. The usual very excellent Junior Academy exhibits were in evidence.

HARVEY A. ZINSZER, *Delegate.*

REPORT OF COMMITTEE ON CONSERVATION AND ECOLOGY

The committee concentrated chiefly on two projects, namely, the Academy National Monument project at Rock City, near Minneapolis, and the federal fish hatchery at Farlington. About 5,000 pamphlets describing the concretions and life of the proposed park site have been distributed in different parts of the state. Much progress has been made toward obtaining this area and it is hoped that the project may be completed in 1940.

We are pleased to announce that the federal fish hatchery project has been brought to a successful conclusion. The federal government has appropriated the sum of $100,000, and work has already started on the project.

The Pittsburg members of the committee on conservation, with the assistance of the Pittsburg Chamber of Commerce, have about completed their work on the three following projects:

(1) Seventy acres of reclaimed strip-pit land have been obtained for the purpose of experimenting with alfalfa, sweet clover and fruit trees.

(2) The acidity and alkalinity of water of many strip-pit lakes has been determined and most of these pits have been found suitable for fish life, and

(3) It has been found that the microscopic fauna and flora of the pit lakes is sufficient in quantity for the support of fish life.

H. H. HALL, *General Chairman*

ENDORSEMENT

To the President of the Kansas Academy of Science:

The Kansas Daughters of the American Revolution at the 41st annual state conference were glad to add our endorsement that "Rock City" be made a state park.—MARION SELLYE, *State Regent.*

KANSAS JUNIOR ACADEMY OF SCIENCE

Report of the Kansas Junior Academy of Science Committee,
EDITH BEACH, Contributing Editor

The Kansas Junior Academy of Science committee was enlarged in 1939 to include not only the three members of the general committee, but also one division chairman from each of ten districts into which the state was divided.

Division chairmen: Mr. J. M. Jewett; Mr. H. A. Stephens, Atchison; Mr. R. L. Tweedy, Hays; Mr. Gerald Travis, Norton; Mr. John D. Schwartz, Dodge City; Mr. E. C. Almquist, Hutchinson; Mr. H. R. Callahan, Junction City; Miss Abigail McElray, Topeka; Mr. C. E. Ruff, Arkansas City.

For the first time the Junior Academy has an official publication, the "Junior Academy News Flashes." Two editions have been published, the first by Miss Beach, the second by Doctor Wells and a third edition will be edited soon after the annual spring meeting by Mr. Brownlee. Copies were sent to all the high schools with an enrollment of one hundred or over, and to academy chairmen in other states.

A certificate of membership suitable for framing was recommended by the committee, approved by the senior academy president, and prints were made. Certificates have been sent to all affiliated clubs.

The following students were recommended by the committee for honorary junior members of the A. A. A. S. and their nominations approved by the Senior Academy committee: Harold Green, Pittsburg High School, and Joanna Wagstaff, Lawrence Junior High School.

The committee purchased the silver loving cup authorized at the Pittsburg meeting of the senior academy for the group award. President Schoewe formally presented the cup to the Lawrence Junior High Science Club at an all junior high school assembly.

The Kansas Junior Academy of Science held its annual meeting at the University of Kansas, Lawrence, Friday, March 31, in conjunction with the Kansas Academy of Science. Morning and afternoon sessions were held in the chemistry lecture room, with Bob Akey, president, presiding.

The Kansas Junior Academy has continued its growth by adding fourteeen new clubs to its membership, making a total of 31 clubs, with a total individual membership of over 350.

Two hundred twenty students registered for the meeting, and in addition there were many interested visitors.

Club members from out of town were guests of students, fraternities and sororities Friday night, and a tour of interesting places in Lawrence was provided Saturday morning by the chamber of commerce

A banquet was held at 6:30 Friday evening in the University cafeteria, after which the junior members met with the senior academy to hear a very interesting lecture by Doctor Gould. This was followed by a party mixer for juniors at Robinson Gymnasium.

Numbers presented at both sessions of the Friday program were very interesting, high-grade in character, and well presented. The exhibits were also very commendable. Atchison High School Science Club was able to demonstrate the use of the motion picture camera in photographing the movement which takes place in blood cells. Ambitious students of the Cherokee County Community High School, Columbus, prepared specimens of wild life that

compared very favorably with those of expert taxidermists, Manhattan Science Club had constructed a reflecting telescope which was not only good for looking at the stars and planets, but could be used for a telephoto lens for their cameras Three boys from Lawrence Junior High made a special short-wave radio set that worked as well as the best commercial sets. An electric welder from Junction City High School was especially commendable.

The program and the winners of awards follow:

1. Lawrence High School Ben Franklin Club. Sponsor, R. E. Wood.
   a. What holds an airplane up. Laurie Russell.
2. Lawrence Junior High Science Club. Sponsor, Edith Beach.
   (2d group award and 3d group exhibit.)
   a. The effects of minerals on the growth of white rats. Joanna Wagstaff.
   b. The effects of ultra violet rays on the growth of snapdragon plants. Joan Sisson.
   c. A study of the developing chick embryo. Alan Stutz.
   d. Soil-less plant culture. Elizabeth Prentice.
   (3d, best talk or paper)
   e. Some effects of colchicine on plant growth. Lois Wheeler.
   f. Color and strength endurance of cloth. Jane Miller.
   (2d, demonstration.)
   g. Effect of the amount of water on plants. Loan Kistler.
   h. A comparative study of plant growth in sunlight, semidarkness and with little light. Sally Fitzpatrick.
   i. How to assemble a short wave receiving set. Charles Robertson, Edwin Pringle, Jimmy Murray.
4. Manhattan High School. Sponsors, R. Rogers and Don Parrish.
   (1st group award, 1st group exhibit and 3d individual exhibit.)
   a. The structure of matter and radio activity. David Gates.
   b. Construction of a gas model airplane. Norman Ross.
   c. From pure to applied science. Jean Hummel.
   d. Activities of the Manhattan Science Club. Fred Budden, David Blevins, Gabe Sellers.
5. Oread High School, Lawrence. Sponsor, A. E. Garrison.
   a. Experiments with an Electrocordio Encephaolograph. Samuel R. Crawford.
   b. Possible relationship between brain waves and parapsychological phenomena. Bob Weir.
   c. Experiments with different types of personalities. Margaret Osmond.

AFTERNOON SESSION, 1:30 P. M.

1. Introduction service for new clubs (Dr. W. H. Schoewe, sponsor and president of each of the following clubs):
   Retorts Science Club, Shawnee Mission Rural High School. Sponsor, J. C. Hawkins; president, Vernon Larrowe.
   Stafford Junior High School. Sponsor, Alex Richards.
   Oread High School Science Club. Sponsor, A. E. Garrison.
   Seaman High School Science Club. Sponsor, Katherine Taggart.
   Argentine High School Club. Sponsor, F. S. Hoover; president, Danny Shupe.
   Atchison Science Club. Sponsor, Homer A. Stephens.
   Girard High School. Sponsor, W. V. McFerrin: president, Ruby I. Cline.
   Norton Community High School. Sponsor, Gerald Travis.
   Hill City Memorial High School. Sponsor, William Voss.
   Burlingame Biology Club. Sponsor, Dolf Jennings.
   Caldwell High School Science Club. Sponsor, R. O. Brown.
   Columbus, Kansas. Sponsor, Mr. McClure.
   Madison High School Science Club. Sponsor, E. L. Kirkpatrick.
   Colby High School Science Club. Sponsor, ———.
2. Girard High School Science Club. Sponsor, W. V. McFerrin.
   a. A talk on "How I prepared a frog's skeleton." Winona Bortz.
3. Atchison High School Science Club. Sponsor, Homer A. Stephens.
   a. Microphotography in motion.
4. Pittsburg Science Club. Sponsor, Mr. Huffman.
   a. Helmet for underwater pictures. Nathan Moore, Kenneth Hunt.
   b. Fundamentals of photo engraving.
5. Independence High School Club. Sponsor, Parley W. Dennis. (3d, group award.)
   a. Construction of electric combustion furnace. (Paper and demonstration.) T. C. Furnas, Jr.
   b. Facts concerning the collection of snakes near Independence, Kan. Clarke Self. (1st, best talk or paper.)
   c. The oxidation of three Aminophthalhydrized. (Paper and demonstration.) John Reddy. (3d, demonstration.)
   d. Destructive distillation of corncobs. Paul Wilhelm.
6. Wichita High School East. Sponsor, J. A. Brownlee.
   a. Spontaneous combustion. Catherine Watkins.
   b. Fluorescence and ultra-violet light. Bud Edmonds. (2d, best talk or paper.)

c. Invisible inks. Bob Hull. (1st, demonstration.)
d. Carbon dioxide. Dorothy Brownlee.
e. Carbon monoxide and carbon monoxide detector. Jerry Preston.

7. Stafford High School Club: The value of building science equipment.
8. Election of officers.
9. Announcement of awards.
10. Exhibits (Snow Hall, Room 221).
    a. An electric welder. Frank Weiner, Junction City High School. (2d, individual exhibit.)
    b. Airplane scrapbooks. Jerry Lindenberger, Lawrence Junior High.
    c. Insect collection. Jack Twente, Lawrence Junior High.
    d. Seaman High School, Topeka.
    e. Exhibit. Stafford High School.
    f. Taxidermy. Columbus High School. (2d, group exhibit and 1st, individual project.)

The A. A. A. S. National award for the coming year was awarded to Jane Miller, Lawrence Junior High, and Bob Hull, Wichita High School East.

The following officers were elected for the coming year: President, Gabe Sellers, Manhattan; secretary, Kenneth Hunt, Pittsburg.

The meeting next year will be held at Wichita.

EDITH BEACH, *General Chairman.*
J. RALPH WELLS,
J. A. BROWNLEE.

REPORT OF COMMITTEE ON NATURAL HISTORY HANDBOOKS

The chairman has a short list of desirable booklets, one of which is in manuscript form. This is entitled, "Winter Twigs: The Identification of Kansas Woody Plants by their Twigs," consisting of nine plates of drawings of the common Kansas woody plants and an annotated list containing points not shown in drawings. This will make a booklet of about 24 pages, for which the John S. Swift planograph company is bidding at the rate of $100 for 1,000 copies or $150 for 2,000, the booklet to be an offset process, assembled with a spiral binding.—F. C. GATES, *Chairman.*

REPORT OF RESEARCH AWARDS COMMITTEE

During its three or four years of experience the committee has gradually crystallized its thinking into a few general principles upon which it believes the granting of awards should in general be based.

GENERAL PRINCIPLES

1. The committee considers that the purpose of the awards is to encourage and, to some extent, to reward promising research and researchers.

2. Awards should be granted on the basis of (1) need, (2) evidences of research ability of the individual, and (3) problem significance.

Need. The committee considers that the awards are provided to help financially where help is most needed. The individual who is struggling to make his way in science is preferred, other things being equal, to the individual already well established in science. There is more or less a period of crisis in the finances and morale of every developing scientist. It is in this period that we believe these award funds can be of most service. This principle is not to be construed, however, as excluding the individual already established in research. As a general rule need is greatest where awards have not previously been granted, yet the committee can conceive of cases where a second award might be most worthily bestowed.

Research ability. The committee believes that the research funds should be awarded only where the individual has already sufficiently demonstrated his research insight and aptitude to give definite promise of continued contributions to science.

Problem significance. The broader and deeper the significance of the problem for research, the more worthy is financial aid. The committee would in no wise care to discourage the attack on any problem, no matter how small it may seem to be, provided it is worth investigating, but the greater the significance to science and, to some degree perhaps, to the public, the better.

The committee would like to make this appeal to those in the Academy who are in positions to observe individuals at work, be they students, faculty members, or others, that they keep the committee informed of promising research talent in need of financial help.

The committee realizes that it is not necessary that all the available funds be granted each year, but it hopes that it will receive sufficient applications of the qualities mentioned that all the fund, and more, will be used annually. Surely there are enough worthy cases to use all the funds.

3. As a general rule, the more individuals materially helped by the funds available the better, but there may occasionally be cases where it would be deemed advisable to apportion a larger sum to one individual.

4. The committee would like to see the awards as widely distributed over the state as is feasible, though it realizes that this factor must not be allowed to weigh too heavily in making selections.

5. The committee sees a little danger in granting awards to be used for travel, especially out-of-state travel.

6. One member of the committee made the following excellent suggestion: "Use some of the fund to encourage experimental problems which are not readily classified in any single departmental field but which lie in 'no man's land' between two or more departments. Our Academy might well give impetus to the breaking down of financial and departmental barriers to such fruitful research."

7. At President Schoewe's request, the committee considered the matter of rewards for outstanding service to the Academy or for the outstanding paper of each meeting, etc The committee was of the opinion that the only thing of this kind which might well be done at this time is to give some sort of recognition, such as a plaque which could be hung on the wall, or a medal, to members of long and faithful service who are still living but who have retired from active participation in Academy affairs

The committee by no means feels that it is ready, or ever will be ready to lay down any hard and fast rules for procedure in making selections for awards. The committee will appreciate suggestions. The foregoing are merely the expression of the committee's thinking and experience and of suggestions from others up to the present.

Respectfully submitted,

L. D. Wooster, *Chairman,*
Ray Q. Brewster,
P. S. Albright,
J. C. Peterson.

RESEARCH AWARDS FOR 1939-1940

(A. A. A. S., Academy, and Albert T. Reagan Funds.)

Name and Position of Recipient.	Amount of award.	Source of award.	Problem.
F. L. Carter.................. High School Teacher, Wilson.	$32.50	Albert T. Reagan fund,	A study of the history of the changes in mammal population in western Kansas.
Claude W. Hibbard........... Assistant Curator of Vertebrate Paleontology, K. U., Lawrence.	25.00	A. A. A. S. fund.......	Completion of study of the upper pliocene fauna of Kansas, and relation to the Blanco fauna of Texas.
Andrew Riegel............... Graduate student, F. H. K. S. C., Hays.	25.00	A. A. A. S. fund.......	A study of the variations in growth of blue grama grass.
Charles Wolfson.............. Graduate student, K. U., 821 Ohio Street, Lawrence.	25.00 7.50 $32.50	A. A. A. S. fund....... Academy fund........	Investigations on existence and origin of electrical potential differences in single cells.
A. P. Friesen................. Professor of Physics, Bethel College, North Newton.	35.00	Academy fund........	Determination of optical properties of liquid metals and alloys.

DR. A. E. ALDOUS

NECROLOGY

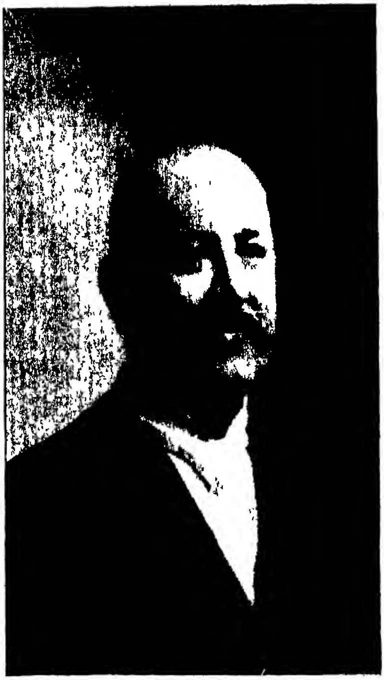
ALFRED EVAN ALDOUS—1886-1938

Dr. Alfred Evan Aldous was born in Ogden, Utah, November 18, 1886; died at Manhattan, Kan., May 4, 1938. He graduated from the Utah Agricultural College in 1910 and entered the U. S. Forest Service that year. In 1911 he took special work in botany and plant ecology at the University of Minnesota. Dr. Aldous came to Manhattan in 1926 from the land classification division of the United States Geological Survey. For many years previously he had been associated with the grazing and range research in the United States Forest Service. He was recognized as one of the leaders in this field of investigation.

During the twelve years Doctor Aldous served as professor of pasture management and agronomist in charge of grass research at the Kansas State College, he established an enviable reputation as a research worker and teacher. He published several experiment station bulletins, reports of the Kansas State Board of Agriculture, and numerous papers in technical journals and in the farm press. In recent years he has been collaborator with the United States Department of Agriculture in their researches on grasses, grazing and pasture improvement.

Doctor Aldous was a member of the American Society of Agronomy, American Association for the Advancement of Science, Sigma Xi, Alpha Zeta, Gamma Sigma Delta, Phi Kappa Phi, Delta Sigma Phi, and several other professional and social organizations. He became an active member in the Kansas Academy of Science in 1937.

In 1916 he married Coral Kerr, who survives him. Two daughters, Lois Geraldine and Joan, also survive.



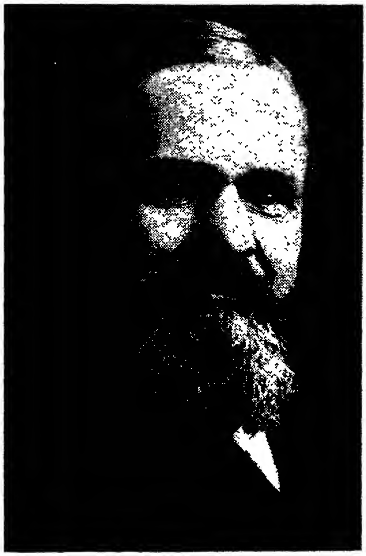
DR. F. W. BUSHONG

FRANCIS WILLIAM BUSHONG—1864-1938

Dr. Francis William Bushong was born in Bird-in-Hand, near Lancaster, Pa., March 17, 1864; died in Port Arthur, Tex., January 10, 1938.

He received his A. B. degree from Franklin and Marshall College in 1885, and an A. M. in 1888. He studied in Leipzg in 1885-1887. An honorary D. Sc. was conferred upon him by the College of Emporia in 1900. Doctor Bushong was professor of natural sciences and German at the College of Emporia 1895-1900; fellow in chemistry, University of Chicago, 1900-1902; professor of chemistry, Kansas City University, 1902-1905; assistant professor organic chemistry, University of Kansas, 1905-1910; associate professor of industrial research, 1910-1913; Mellon Institute, 1913-1914. He had been a research chemist for the Gulf Refining Company since 1915. His research work was chiefly in that field. He was a member of the Chemical Society and the Kansas Academy of Science. He became a member of the latter organization in 1896 and was granted a life membership in 1912. Married March 26, 1895.

He is survived by his wife; a daughter, Mrs. K. W. Hoffpauir, Port Arthur; a son, P. D. Bushong, Gonzales, Tex., and six grandchildren.



J. L. COPLEY

JOHN TRUBY COPLEY, 1856-1938

Rev. John T. Copley was a minister in the Presbyterian Church and served many years as a pastor or missionary, and in special capacities. He was a man of high intelligence, and this, with a strong memory, enabled him to meet an affliction of defective eyesight, and finally of blindness, with cheerfulness, and to perform able ministerial service. He was of a deeply religious nature, and at the same time a competent student of mathematics and physical sciences. He was especially interested in archeology and meteorology, and in March, 1935, contributed a paper to the Academy program embodying some of his observations on tornadoes.

Mr. Copley was born in Pennsylvania, September 2, 1856, and came to Perry, Kan., in 1866. He attended Highland College and Kansas State College. He married Mrs. Elizabeth Trumbull in 1885. After her death in 1923 he made his home with his daughter, Mrs. Margaret Buchholtz, in Olathe, Kan.

Mr. Copley's membership in the Academy began in 1903, and later he became a life member. He was a regular attendant at the annual meeting, and much interested in the papers presented, and in meeting old friends, the number of whom became very small. He died May 5, 1938, in the University of Kansas hospital, Kansas City.

C. L. HARRIS

CURTIS L. HARRIS—1862-1938

Curtis L. Harris was born at Mt. Union, Ohio, May 31, 1862, and died at El Dorado, Kan., April 24, 1938.

Mr. Harris grew to manhood in Alliance, Ohio, was educated in the public schools and graduated from the Liberal Arts Department of the Mount Union College in 1883. He subsequently read law and was admitted to the bar at El Dorado, Kan., June 30, 1887. He began the practice of law in El Dorado, where he maintained an office for more than 50 years. He was active in many civic affairs in El Dorado. Mr. Harris was respected by his friends and associates. They all speak in the highest terms of the amount and character of the work done by him. He was a member of the American, Kansas State and Butler County Bar Associations.

He loved the great outdoors and for many years kept a cabin in the country. His farms were a haven for wild life, and he was so deeply interested in science that he became a member of the Ornithological Society of America, the American Association for the Advancement of Science, and the Academy of Science. He joined the latter in 1928. He is survived by a daughter, Mrs. Frank W. Robinson; a grandson, Harris Robinson; and a granddaughter, Phyllis Robinson, all of El Dorado.

DR. EDWARD L. NICHOLS

EDWARD L. NICHOLS—1854-1937

Dr. Edward Leamington Nichols was born in Leamington, Warwickshire, Eng., on September 14, 1854; died West Palm Beach, Fla., on November 10, 1937. Although born in England his parents were American stock. He matriculated as a student at Cornell at the opening of the sixth year of instruction at the University. After receiving the B. S. degree in 1875 he studied successively at the Universities of Leipzig, Berlin, and Göttingen, from the last of which he received the doctorate in physics in 1879. Returning to this country he received appointment to a fellowship at Johns Hopkins University. The following year he went with Edison at Menlo Park. After serving for two years as professor of physics and chemistry at Central University in Kentucky, and for four years as professor of physics and astronomy in the University of Kansas, he returned to Cornell in 1887, where he remained head of the department of physics until his retirement from active teaching in 1919.

Professor Nichols attained a place of high scientific distinction. His ex-

tensive publications embraced almost every branch of the physics of his day. He was the recipient of many honors. In recognition of his pioneer work he was awarded three medals, the Ives Medal of the Optical Society, the Elliott Cusson Medal of the Franklin Institute and the Rumford Medal of the American Acadamy.

Professor Nichols, more than any other physicist of his generation, emphasized the possibilities of industrial research. As president of the American Physical Society, of Sigma Xi, and of the American Association for the Advancement of Science, he kept continually before the public the importance of scientific work. As dean of the College of Arts and Sciences for two years, he advocated and initiated numerous educational practices of a progressive character. Professor Nichols became a member of the Kansas Academy in 1885 and was elected an honorary member in 1897.

HARRY LLOYD SHAFFER

Harry Lloyd Shaffer—1908-1938

Harry Lloyd Shaffer was born in Bunker Hill, Kan., August 30, 1908, and died at Ardmore, Okla., on August 3, 1938. He attended the elementary schools in his home town and the high school at Waldo, Kan. He graduated from the State University in June, 1936, majoring in geology. He assisted in this department in 1935-1936.

On September 4, 1937, he married Kalita Kirkendall, of Kansas City, Mo. Mourning his early death are, besides his wife, his father, stepmother, two younger brothers and six younger sisters, all of the home.

Mr. Shaffer was employed by the Phillips Petroleum Company and was stationed at Ardmore, Okla., as a geologist. He has been a member of the Academy since 1931.

In the premature death of Mr. Shaffer the Academy and the geological profession have lost a promising young man. He was of a quiet nature, a willing and hard worker, and was well-liked by all those who knew him.

J. M. SCHAFFNER
(*Photo courtesy E. E. Sherff*)

JOHN HENRY SCHAFFNER—1866-1939

On January 27, 1939, Prof. John H. Schaffner, long-time professor of botany at Ohio State University, died at Columbus, Ohio. He was born at Agosta, Iowa, July 8, 1866. Not very long after, his family moved to Clay county, Kansas, where he grew to manhood, making the acquaintance of the prairie flora. In 1893 he received an A. B. from Baker University, and a master's degree from the University of Michigan in 1894. Later he attended the University of Chicago, and spent the year 1907-'08 at Zürich. Before going to Chicago he was professor of natural science at South Dakota, and in 1897 he joined the faculty of Ohio State University, where he remained until his death, teaching, head of the department 1908-1918, and doing research work. He married Cordelia Garber, of Mt. Vernon, Ohio, in 1916. They had three children.

In his research work, Professor Schaffner was particularly interested in life histories of various angiosperms, the flora and ecology of Ohio and Kansas, taxonomy, the nature and control of sex, especially in those cases in which sex was not controlled by chromosome mechanisms, phylogeny and evolution of plants, and the plant family Equisetaceae. He has published a number of botanical books, including particularly "Trees of Eastern United States" and "The Flora of the State of Ohio." He contributed a large number of papers to various scientific journals, papers which have expressed original ideas and careful experimentation. He was a life member of the Kansas Academy of Science. To the state flora he contributed a study of the Equisetaceae in Kansas, based on collections in the state herbarium and his personal field trips. With his sudden death the science of botany lost not only a devoted research man, but also a modest, unassuming, unselfish, enthusiastic gentleman.

L. C. R. Smyth

LUMINA C. R. SMYTH—1872-1939

Dr. Lumina C. R. Smyth, assistant professor of biology in Ottawa University, 1921-1924, died at the age of 67 years, at the Fairview Park Hospital in Cleveland, Ohio, February 2, 1939, after a six-weeks illness.

Doctor Smyth was the second woman to receive a doctor of philosophy degree from Ohio State University and was at one time curator of the Kansas State Museum in Topeka, succeeding her husband, B. B. Smyth.

She was a native of Woodstock, Ohio, and was a direct descendant of John Cotton, a famous figure in New England history. She was educated at Ohio State, receiving there her B. S., M. S., and Ph. D. degrees.

Before coming to Ottawa, she taught in Washburn College and in the high schools at Altoona, and Munden, Kan.

Friends recall with pleasure her lovely social graces and her beautiful singing voice. During the period of her sojourn in Topeka she was regarded as an outstanding soprano singer, appearing on various occasions as a soloist. For some time she was soloist in Doctor Sheldon's church in Topeka.

At Ottawa, in addition to her teaching, she was very helpful in assisting with the Crevecour collection of insects.

She returned to Ohio in 1924, living in Columbus until 1930, when she removed to Cleveland. She is survived by a sister, Mrs. W. S. Eyman, in Ohio; a brother in Florida, and three stepchildren in California.

E. AMBROSE WHITE

E. AMBROSE WHITE—1870-1938

E. Ambrose White was born at Wells Tannery, Pa., October 7, 1870, and died at his home at Lawrence, Kan., on September 18, 1938. He joined the Kansas Academy of Science in 1904, served as its secretary from 1918-1929, and for several years prior to his death had been a life member of the Academy.

At the age of fourteen he came to Kansas with his parents and was graduated from the Kansas State Teachers College at Emporia in 1899. Later he attended the University of Kansas and received the A.B. degree in 1904, and the M.A. in 1909. Following graduation from the University he became teacher of chemistry in the Kansas City, Kan. high school (now Wyandotte), and after serving in that capacity for seven years was made principal of the school. Soon after resigning the position as principal he joined the Kansas University staff as instructor in chemistry and custodian in 1918, and was promoted to assistant professor three years later. As custodian of the department, Mr. White's services were of incalculable value, for by his ability in management and organization he systematized the task of supplying each student with all of the necessary materials with the least loss of time on the part of the student, and at minimum cost.

Mr. White did some pieces of notable research, particularly in the purification of carbon dioxide at high pressure, although his greatest enjoyment was in teaching. Students were always uppermost in his mind and he spent many hours with elementary students, explaining the fundamentals of chemical calculations. This work which many do drudgingly, he did enthusiastically. In fact, he had an abundance of enthusiasm for everything he did, whether it be teaching, fishing, or entertaining chemical students and faculty at picnics at his surburban home.

His many friends join his widow, Mrs. Ella (Howell) White and their three daughters, Mrs. Fred Butcher, Mrs. Ben Batchelor, and Miss Jeanette White, in mourning his death.

REPORT OF RESOLUTIONS COMMITTEE

The resolutions committee offers the following resolutions:
Be it resolved:

1. The Kansas Academy of Science extends its thanks and appreciation to the University of Kansas for the excellent facilities extended to the Academy for conducting the various sessions.
2. That, through the secretary, we extend to Dr. Charles A. Shull and to Dr. Laurence McKinley Gould our appreciation for their interesting and instructive lectures.
3. That the thanks of the Academy be extended to the Phi Sigma and Sigma Xi societies of the University of Kansas for providing the two evening speakers for the meeting.
4. That we extend well deserved thanks to the officers and various committees, particularly to Doctor Schoewe, Doctor Wheeler and the local committee for the splendid preparations for these meetings.
5. That we extend special thanks to Dr. Roger C. Smith, secretary, for his untiring efforts and friendly coöperation with all the officers and committees so necessary to a successful meeting.
6. That we express our appreciation to Miss Beach, Doctor Wells and to Mr. Brownlee for the fine way in which they have developed the Junior Academy of Science, and to the Lawrence Chamber of Commerce in connection with the Junior Academy trip.

O. P. Dellinger, *Chairman*,
Mary T. Harman,
R. E. Bugbee,
Committee.

REPORT OF THE NOMINATING COMMITTEE

President, H. H. Hall, Kansas State Teachers College, Pittsburg; *president-elect*, E. O. Deere, Bethany College; *vice-president*, F. C. Gates, Kansas State College; *secretary*, Roger C. Smith, Kansas State College; *treasurer*, H. A. Zinszer, Fort Hays Kansas State College.

Executive Council (additional members): W. H. Schoewe, Kansas University; L. D. Bushnell, Kansas State College; R. H. Wheeler, Kansas University.

Associate Editors: R. E. Mohler, McPherson College, term expires 1942; A. B. Cardwell, Kansas State College, term expires 1942.

Wm. H. Matthews, *Chairman*,
W. J. Baumgartner,
J. Willard Hershey,
Geo. A. Dean,
R. Taft,
Committee.

PAPERS AND ABSTRACTS

SEVENTY-FIRST ANNUAL MEETING, LAWRENCE, 1939

Conservation of Our Natural Areas

WALTER H. SCHOEWE, University of Kansas, Lawrence, Kan.

CONSERVATION IN THE ACADEMY

The Kansas Academy of Science (Kansas Natural History Society) was founded for the purpose of "securing the advantages arising from association in scientific pursuits and of giving a more systematic direction to scientific research in our state." (*1*) In my report of last year (*2*) I pointed out that the Academy from its very start was not content to come together once a year solely for the purpose of reading scientific papers and making new friends. On the contrary, it busied itself with several major projects, of which the following ones were the most important: (1) geological survey project, (2) museum project, and (3) the library project. It is my intention at this time to consider a fourth interest of the Academy, namely, conservation. The conservation movement may be thought of as dating back to the very beginning of the Academy in 1868. It was an early thought of the founders of the Academy that large scientific collections would be made by the members and that these would be secured to the state. At the organization meeting one of the officers elected was a curator whose duty was to be in charge of the collections. Whether the founders of our Academy thought of the collections from the new point of conservation, and whether the legislature in instructing the Academy to place and keep for public inspection geological, botanical and other specimens was conservation minded, or whether the collections were to serve an educational purpose, is debatable. It is certain, however, that some of the early members were conservationists. This was especially true of Professor Benjamin Franklin Mudge, the first president of the Academy. Mudge was a great collector and was especially concerned with the preservation for Kansas of the rare specimens, many of which were finding their way out of the state. The first real record concerning conservation in the Academy dates back to 1912, when the Academy moved to go on record as favoring a national law for the protection of bird life in the United States (*3*). A plea to preserve places of beauty was made in 1921 (*4*). Mr. H. deForest, a member of the Academy, had been appointed by the Ecological Society of America as its representative in Kansas, and as such representative gave a paper on state parks. His paper was a plea to preserve places of beauty and historical interest in the state, and asked that a committee be appointed from the Academy to assist him in that work. On motion by Dr. E. H. S. Bailey, of the University chemistry department, the first conservation committee of the Academy was appointed. This committee, then called the parks committee, consisted of Dr. H. deForest, chairman, and Drs. Roy Rankin, R. K. Nabours, and R. C. Moore (*5*). At the fifty-fourth annual meeting, held at Manhattan on February 17 and 18, 1922, Professor J. W. McColloch, of the entomology department at Kansas State College, Manhattan, read a paper on "The Preservation of Natural Areas in Kansas." This paper, as well as a second one by the same author on "The Ecological Features of Kansas," read

the following year, formed the nucleus of an article published in the *Naturalist's Guide to the Americas* (*6*). In 1925 the parks or ecological committee reported that during the past year the committee had continued coöperation with the committee on the preservation of natural conditions of the Ecological Society of America. According to this report (*7*), a general account of the ecological features of Kansas was prepared for the *Naturalist's Guide*. The descriptions of twelve natural areas in Kansas which were submitted to the committee were edited and prepared for publication; thirteen additional areas were located and described. A series of maps were also prepared showing the various ecological features of the state and the location of the several areas suggested for preservation. The committee recommended that the coöperation with the Ecological Society of America be continued and that additional natural areas be described. Furthermore, the committee suggested that the Academy sponsor and undertake an ecological survey of the state. As far as may be learned from the minutes printed in the TRANSACTIONS, the parks committee existed until the death of its chairman, Professor James W. McColloch, on November 11, 1929. At the Lawrence meeting in 1931 the Academy voted to have a natural history survey and ecology committee. On taking office, President Dr. Roger C. Smith appointed the following to constitute the committee: W. Knaus, E. H. Taylor, and W. H. Schoewe, chairman (*8*). This committee began at once to make a survey of areas in Kansas which, because of scenic beauty, geological interest, and ecological features, should be preserved for posterity. Efforts were made at that time to interest the chamber of commerce at Minneapolis, Ottawa county, to take steps in securing the area of concretions known as "Rock City" three miles southwest of the city, for a state park. Although interested, funds to purchase the site were reported lacking by the Minneapolis chamber of commerce. Perhaps the most significant move by the Academy in relationship to the natural history and ecology committee took place on April 19, 1935, when President W. J. Baumgartner called for a joint meeting of the executive council of the Academy, the natural history and ecology committee, and the publications committee. At this meeting, the natural history and ecology committee outlined an 8-point program which was approved by the executive council and was given a grant of $50 to carry out its program. Aided by an additional grant of $50 from the University of Kansas graduate research committee, a fairly detailed geologic and biologic survey of "Rock City" was made in the spring of 1936. On April 3, 1937, the committee presented a symposium on Rock City before the Academy. At this same meeting, on recommendation of the natural area and ecology committee, the Academy went on record as being opposed to the construction of an irrigation tunnel through the Rocky Mountain National Park, a resolution which was forwarded to the proper authorities at Washington, D. C. The Academy also voiced itself in favor of killing any attempt to commercialize our national parks and monuments. At this meeting also the name of the committee on natural areas and ecology was officially changed to the committee on conservation and ecology. Previous to the Pittsburg meeting held in 1938, the committee on conservation and ecology prepared a 16-page booklet, "National Monument Project of the Kansas Academy of Science," a booklet describing and illustrating the area of concretions near Minneapolis, in Ottawa county. Being convinced that "Rock City" is of national monument caliber, it was proposed to recommend the site for a

national monument rather than for a state park. Ten thousand copies of the booklet were printed by the state printer and distributed widely over the state. As a direct result of this publication and an address given by the chairman of the committee at Minneapolis, the Rock City National Monument Association of Ottawa county, Kansas, was organized. The function of this new association is to promote the establishment of Rock City as a national monument. At the Pittsburg meeting your speaker, as president-elect of the Academy, enlarged the personnel of the committee on conservation and ecology and at the same time divided its work under separate subcommittees. For the first time, the duties of the committee were definitely set forth and certain objectives for 1938-1939 were outlined. Among the latter was instruction to the parks subcommittee to make a survey of the area known as the "Monument Rocks" and also of the "Sphynx" in Gove county for the purpose of determining the advisability of establishing a state park there. A report of this project will be made somewhat later during the morning by members who conducted the survey. This, then, is the history of the conservation movement from the beginning of the Academy up to the present time.

THE ROCK CITY PROJECT

The movement to have the Rock City area set aside as a national monument is undoubtedly the most important project ever undertaken by the Academy's committee on conservation and ecology. Unfortunately, the Academy's dream thus far has not been realized. It is therefore not out of place to record here in outline form the history of the project, step by step, in order that a permanent record may be had for the Academy and for its future committees on conservation and ecology who may have to complete the task that we have started. How long will it take to have "Rock City" set aside either as a state park or national monument? I do not know. We are determined, however, that some day the concretions will be preserved and set aside for the people to enjoy, and that for all time.

1. 1931. Original investigation of natural areas in state. Chamber of Commerce at Minneapolis urged to secure "Rock City" and establish a state park.

2. 1933. Special attention directed toward Rock City as the most likely site of a state park.

3. 1935 (April 19). Joint meeting of executive council, committee on natural areas and ecology and committee on publications at Lawrence. Eight-point program outlined by committee on natural areas and ecology, approved by executive council, given a grant of $50 to carry out program.

4. 1936 (Spring). University of Kansas graduate research committee granted $50 toward geological survey of Rock City. Geologic and biologic survey made at Rock City. Proposed to establish national monument rather than state park.

5. 1936 (June 26). Typed report, accompanied by photographs and map sent to director of National Park Service calling attention to "Rock City" and requesting official investigation of area.

6. 1936 (December 1). Letter sent to Mr. Arno Cammerer, director of National Park Service, calling attention to report and letter sent to him on June 26, to which no reply had been received and no acknowledgment had been made.

7. 1936 (December 24). Letter received from Acting Director A. E. Demaray, acknowledging letter of December 1 and stating that "although there is some evidence that your letter of June 26 was received, it did not come to the

attention of those detailed to handle such matters and cannot be located." Requested that the report be resubmitted.

8. 1937 (January 6). Report resubmitted to Mr. A. E. Demaray.

9. 1937 (February). House joint resolution No. 8 introduced by Representative U. E. Hechert of Ottawa county. Resolution designed to create a temporary commission to study and investigate natural areas in Kansas. Resolution never came up for consideration.

10. 1937 (March 8). Same report sent to each of the United States senators and representatives from Kansas at Washington, D. C., informing them of the action taken by the Academy's committee and suggesting to them to help further the cause. Letters received from all senators and represenatives heartily endorsing the project and pledging full support and coöperation with copy of letters sent by them to the National Park Service.

11. 1937 (April 3). "Symposium on Rock City" by members of committee's survey before the Academy at Emporia.

12. 1937 (April 14). Received letter from Acting Director A. E. Demaray as follows:

UNITED STATES DEPARTMENT OF THE INTERIOR,
NATIONAL PARK SERVICE, WASHINGTON, April 14, 1937.

Mr. Walter H. Schoewe, Chairman, Committee on Natural Areas and Ecology, Kansas Academy of Science, Lawrence, Kan.:

MY DEAR MR. SCHOEWE—Reference is made to your previous correspondence with us regarding the preservation of the sandstone concretions known as "Rock City," located near Minneapolis, Kan.

The report of our regional geologist on this site has been received. There follow pertinent quotations which will be of interest to you:

> "As to the advisability of setting aside 'Rock City' there is no question as to its geological interest. Its interest centers however on only one phase of a single geological process, the formation of round sandstone concretions, and this process is not of major importance, having to do merely with the cementation of sandstone, chemical precipitation from solution and possibly with crystal growth. The peculiarities of cross bedding in fresh water sandstone are shown in the concretions and the differential erosion of sandstone through the action of wind and rain is also illustrated.
>
> "The great concretions cannot be destroyed through vandalism. Names will be carved upon them, but this cannot be prevented even if the area is set aside as a state park unless a guard is constantly on duty."

If these concretions demonstrated the work of a major geological force in the modeling of a physiographic region, they could be considered further for establishment as a national monument. However, judging from the statements quoted above, it appears that, although they are interesting and unusual, they represent a minor phase of a single geological process. With this in mind, I don't feel that we can recommend it for establishment as a national monument. Instead, I suggest some arrangement whereby a wayside shrine could be erected at or near the site directing interested visitors to it and explaining the geological processes involved.

If you are interested in this idea, I suggest that you write to the second regional officer of this service, 800 Keeline Building, Omaha, Neb. Members of his staff are familiar with the site, and will be glad to assist you in the preservation and proper use of the concretions.

Sincerely yours, A. E. DEMARAY, *Acting Director.*

13. 1937 (May 27). Publication of 16-page booklet called "National Monument Project of Kansas Academy of Science." 10,000 copies printed by state printer, and widely distributed.

14. 1938 (January). Organization of Rock City National Monument Association of Ottawa county, Kansas.

15. 1938 (March 7). Letter received from Senator Arthur Capper in regard to Rock City, letter prompted by activity of Rock City National Monument Association of Ottawa county, Kanas.

16. 1938 (March 10). Wrote to Senator Capper telling status of Rock City project and including copy of letter received from Acting Director A. E. Demaray, with statements meeting objections cited by National Park Service.

17. 1938 (March 16). Letter from Senator Capper stating agreement with chairman's letter of March 10 and concluding that for the present there is nothing that can be done.

18. 1938 (December). Subcommittee on parks contact owners of Rock City and try to make arrangements for securing the site.

19. 1939 (February). House joint resolution No. 7, committee on state parks and memorials. Resolution sponsored by committee on state parks and memorials of Kansas house of representatives, declaring certain areas in Kansas (including Rock City, Sphynx, Monument Rocks, etc.) as having unusual historical interest and giving state forestry, fish and game commission authority to take and acquire such lands in the name of the state, by donation, devise or bequests.

THE HISTORY OF OUR NATIONAL PARKS AND MONUMENTS

Introduction

The slowness of our progress or apparently getting nowhere with our Rock City project, accentuated by the refusal of the National Park Service to recommend the area to the President of the United States for establishment as a national monument, naturally had its depressing effects upon the committee on conservation and ecology. Is it worthwhile to continue the project? and Is there any hope that we can ever be successful in preserving the unusual concretions near Minneapolis? were questions which every now and then confronted the committee. There never was any doubt in the minds of the committee members as to the worthiness of our endeavor and the idea that the Rock City site was of national monument caliber. If the reasons cited in the letter received from Acting Director A. E. Demaray under date of April 14, 1937, were the only ones which disqualified the Rock City area as a national monument, then I determined the fight should never be given up. Even a casual survey of our national monuments, including some of our national parks, was sufficient to show that our proposed area lacked nothing that the existing national monuments, and even some of the national parks possessed. It was then that I began to wonder whether all national monuments were created only after untiring efforts had been expended, numerous difficulties had been met and overcome and Job's patience had been matched. Perhaps our experience, after all is the normal one, and the requirements to have a national monument created are: (1) incessant propaganda, (2) ceaseless work, (3) endless patience, and (4) and an undefeatable spirit. So it was not difficult for me, especially on the suggestion and encouragement of Dr. Robert Taft, to select as my presidential address, the conservation of our natural areas, particularly as illustrated by our national parks and monuments.

Today we have in the United States 27 national parks proper and 77 national monument (*9*). In addition to these there are national historical parks, national military parks, cemeteries and national battlefield sites, as well as a number of miscellaneous memorials and the Boulder Dam Recreational Area, all under the supervision of the United States National Park Service. Last year (1938), 6,976,296 people visited the 27 national parks and another 2,-029,808 the national monuments. All in all, 16,233,688 people visited our federal park system last year (*10*). This number is approximately 1,000,000 more visitors than in 1937. (Table 1.) In addition, 4,723, 39,645 and 175,000 people

Table 1. Visitors to Our Federal Park System, 1937 and 1938

	1937	*1938*
National parks	7,012,808	6,976,296
National monuments	1,770,486	2,029,808
National historical parks	770,861	728,060
National military parks and cemeteries	1,692,287	2,877,655
National battlefield sites	210,776	168,566
Miscellaneous memorials	3,287,475	2,888,503
Boulder Dam Recreational Area	389,294	564,800
	15,133,432	16,233,688

visited the Isle Royale National Park, Richmond Battlefield Park and the Badlands National Monument, respectively, in 1938, parks in which federal jurisdiction is pending. The most recent addition to our national monuments was announced during January of this year (1939) by Secretary Ickes as the Homestead National Monument of America in Gage county, Nebraska (*11*).

Today we take our national parks and monuments more or less for granted. And yet, there was no national monument in existence until 1906, and all but Yellowstone, Yosemite, Sequoia, General Grant and Mount Rainier national parks were created since 1900, less than 40 years ago. One can hardly believe that the mile-deep gigantic chasm in Arizona known as the Grand Canyon did not become a park until 1919, although a portion of it had been proclaimed a national monument in 1908. What, then, are these national parks and monuments? Why do we have them? Let us answer the first question by viewing some typical scenes of our national parks and monuments by means of the colored slides so graciously loaned to us by the National Park Service.

(At this point, colored slides of our national parks and monuments were projected on the screen.)

I am sure that you will agree with me that our national parks and monuments are a gallery of nature's scenic masterpieces and like the famous masterpieces of Rembrandt, Raphael, Reubens, Leonardo de Vinci, are priceless gems ever to be treasured. They are nature's best, the supreme examples. They may also be thought of as natural museums and nature's classrooms, where not only may one see and learn of the past, but where the forces of nature are still operating and are demonstrating in no uncertain terms that the present is the key to the past. To be sure, our parks and monuments are also recreational centers, or the nation's playgrounds. Nevertheless that function is secondary to the preservation of the world's supremest scenery and the conservation of portions of our primitive vegetation and animal life. To me the story of our national parks and monuments is most interesting and stimulating in giving encouragement to continue the good fight to preserve in our own state of Kansas certain natural areas for all the people for all times.

PERIOD BEFORE 1915—UNALLOYED CONSERVATION

The national parks movement may be said to have come into being in 1915. Previous to this time our people were not park conscious, although 14 parks were in existence. The existing parks were practically without administration. "Business necessarily connected with their upkeep and development was done by clerks as minor and troublesome details which distracted attention from more important duties; there was no one clerk whose entire concern was with the national parks" (*12*). Information relative to the parks and monuments was primarily to be had from the advertising folders of competing railroads. Our people, in thinking of scenery, looked to the Alps and to some extent to the Canadian Rockies.

The period before 1915 might be considered the period of unalloyed conservation. Areas were set aside motivated purely by the instinct to preserve or to prevent private exploitation. The first area to be set aside by the federal government was the Hot Springs National Park in Arkansas. This area now established as a national park was, when withdrawn by congress in 1832 from the public domain from settlement or sale, designated as the Hot Springs Na-

tional Reservation. Not until 1921 was its classification changed to that of a national park. The sole purpose of congress in setting aside this area was apparently to prevent private exploitation. The law passed by congress merely stated that the area containing the medicinal springs "shall be reserved for the future disposal of the United States" (*13*). The medicinal properties of the hot springs were known locally for a long time. When the curative properties of the springs became more widely known, fear arose that this part of the public domain might pass into private ownership and the hot springs would be privately exploited. Congress had no plan in mind in creating the Hot Springs Reservation. It was only concerned with preventing private exploitation. Perhaps some day a use for the hot springs might be found for the people.

THE BIRTH OF THE NATIONAL PARK IDEA

The first true national park established in the United States was Yellowstone National Park in 1872. Unlike the Hot Springs Reservation, which was set aside to prevent private exploitation, Yellowstone National Park was created chiefly in order to preserve the natural wonders contained in the park area. With its creation was born the national park idea. Interestingly enough, the men who started the movement to make the Yellowstone area a national park at first thought of Yellowstone as a "profitable speculation" (*14*), and had in mind "to take up the land surrounding the principal phenomena and exploit them as commercial enterprises." According to reports the territory was to have been split up into a number of tracts, one of which was to have been assigned to each member of the exploring party. The members were then to file upon the land under the homestead laws and grow rich out of the rush of sightseers (*15*). This idea, however, did not appeal to one of the explorers who was sitting around the campfire on the evening of September 19, 1870, a day or so before the party broke camp. This member, a Mr. Cornelius Hedges, a Montana lawyer, suggested instead "that there ought to be no private ownership of any portion of that region, but that the whole of it ought to be set apart as a great national park, and that each one of us ought to make an effort to have this accomplished" (*16*). Mr. Hedges' suggestion met with instant approval of all members save one, and all began to work enthusiastically toward the creation of Yellowstone National Park so that within two years after the birth of the national park idea, as voiced by Mr. Hedges, congress passed the bill creating Yellowstone National Park as the first true national park. President Grant signed the bill on March 1, 1872. As expressed by Gen. Hiram M. Chittenden: "It was a notable act, not only on account of the transcendent importance of the territory it was designed to protect, but because it was a marked innovation in the traditional policy of governments. From time immemorial privileged classes have been protected by law in the withdrawal, for their exclusive enjoyment, of immense tracts for forests, parks, and game preserves. But never before was a region of such vast extent as the Yellowstone Park set apart for the use of all people without distinction of rank or wealth" (*17*). The bill creating Yellowstone National Park explicitly stated (*18*), first, that the area is "dedicated and set apart as a public park or pleasure ground for the benefit and enjoyment of the people" and second, that the Secretary of the Interior "shall provide for the preservation from injury or spoliation of all timber, mineral deposits, natural curiosities, or wonders

within the park, and their retention in their natural conditions." The bill also provided "against the wanton destruction of the fish and game found within the park and against their capture or destruction for the purpose of merchandise or profit." Also, jurisdiction over the park was to rest with the Secretary of the Interior. Before the park was finally created, it took many public lectures, scores of published magazine articles, and numerous newspaper accounts, together with untiring work and concerted action on the part of many, to convince the people that such wonders really existed and to cause several independent expeditions and a government expedition to be sent out to the Yellowstone area in order to confirm the various reports and hunters' tales describing this wonder spot of nature Although the enthusiasm which followed the verification of the reality of the amazing phenomena occurring around the headwaters of the Yellowstone spread rapidly in favor of creating a national park, some opposition to the idea was encountered, as may be seen from the following, a part of an editorial appearing in the Helena *Gazette:* "In our opinion the effect of the measure (bill to create the Yellowstone National Park) will be to keep this country in wilderness and shut out for many years the travel that would seek the curious region if good roads were opened through it and hotels built therein. We regard the passage of the act as a great blow struck at the prosperity of the towns of Bozeman and Virginia City, which might normally look for considerable travel to this section if it were thrown open to a curious but comfort-loving public" (*19*). This opposition, however, was short lived, for the records show that Col. Martin Maginnis, the editor of the Helena *Gazette,* as delegate from Montana, was in favor of Congress appropriating $100,000 for the park and in taking "some action to preserve these wonderful and beautiful curiosities (geysers) before it is too late" (*20*). Later he voiced his approval again by favoring the Williams amendment of June 13, 1878, by stating, "It would be true economy in the end to preserve these beautiful works of nature, and not allow them to be destroyed by vandals" (*21*). To us Kansans the creation of the Yellowstone area as the first national park is more than of passing interest. In the first place, the bill to create the park was introduced into the United States Senate by Senator Samuel C. Pomeroy, of Atchison, Kan., who at that time was chairman of the Senate committee on public lands. But of still greater interest to us as Academy members is the fact that one of our own members, Mr. Joseph Savage, was a member of the second Hayden expedition sent out by the federal government to explore the few-months-old Yellowstone National Park. Mr. Joseph Savage served as the Academy's secretary in 1876 and 1877 and as its second vice-president from 1879 to 1882 and again in 1884. Mr. Savage discovered the petrified forest on Amethyst mountain and was in reality responsible for the naming of that mountain. As related by Savage, on August 1, 1872, while exploring among the petrified trees discovered by him, Savage turned over a large section of a petrified tree which had been hollow, but which then was filled with beautiful crystals of amethyst. On returning to camp one of the men in camp seized a good sized specimen from Savage and went shouting through camp, "Amethyst, amethyst." The following day, Dr. A. C. Peale, the expedition's mineralogist, accompanied by Savage and other members, returned to the mountain and found other fine specimens of amethyst. From that day to the present, the mountain is known as Amethyst Mountain (*22*). Amethyst Mountain has an elevation of 9,400 feet and is

located south of the Fossil Forests, on Specimen Ridge, in the Tower Falls-Soda Butte section of the northeastern part of the park.

The initial period of national parks conservation terminated with the establishment of the Casa Grande National Park in 1889, seventeen years after the Yellowstone area became a national park. The instinct to preserve anything of importance was still paramount, for when newspapers and scientific magazines called attention to the ethnological importance of the Casa Grande ruin, congress created the park. Casa Grande is a large ruin of prehistoric days, located not many miles north of the boundary of Sonora, near the Gila river in southern Arizona. As viewed today, the ruin contained nothing to earmark it as a national park. Later, in 1918, congress realized its error and reclassified the ruin as a national monument.

THE MIDDLE PERIOD—1890-1915

In 1890, Yosemite, Sequoia, and General Grant National Parks were created. These were followed in 1899 by Mount Rainier, and in 1901 Crater Lake National Park came into being. By this time the national park idea had taken root and was rapidly growing. For the first time the people at large became national park-minded. Two important park principles or policies developed during this middle period. Laws forbidding hunting in the national parks were passed. This new principle focused public attention upon an entirely new idea, namely wild life conservation, and laid the foundation for practically all future nation-wide wild life conservation. Dr. William T. Hornaday, director of the New York Zoölogical Park, played a large part in this new conservation movement. It was he who wrote a book called "Our Vanishing Wild Life," in which he pleaded for immediate action on the part of all people to preserve the wanton destruction of the nation's wild life. It is interesting to note in this connection that another of our own Academy members, Professor Lewis Lindsay Dyche, of the University, did his share to help in this movement. As stated by Hornaday, "Professor Dyche proved to be a very live wire, and his activities have covered the state of Kansas to its farthest corners. We love him for the host of enemies he has made—among the poachers, game butchers, pseudo-'sportsmen' and lawbreakers generally. The men who thought they had the 'pull' of friendship for lawbreaking were first warned, and then as second offenders, hauled up to the bar, one and all" (*23*). It will be remembered that at the forty-fifth annual meeting, held on December 23 and 24, 1912, the Academy passed a resolution favoring a national law for the protection of bird life in the United States and instructing the secretary to communicate this action to the Kansas congressmen at Washington, urging them to support such a bill if presented to Congress (*24*). The records do not show who originated the resolution but circumstantial evidence points to Dyche, who in 1908 was appointed state fish and game commisssioner for Kansas by the governor of our State and who served in that capacity until 1915.

The second concept developed during the middle period was "that natural beauty of supreme quantity is essentially a national possession"(*25*). This is illustrated by the fact that congress reclaimed the Yosemite Valley and Mariposa Big Tree Grove in 1905, after it had ceded both to the state of California for a state park in 1864. The desire to have national parks waxed strong, particularly in the western and mid-western states. If California can have

national parks, why cannot we? was the feeling of other states. So it was that in 1903 and 1904 national parks were created by Congress in North Dakota, South Dakota and Oklahoma. These parks, Wind Cave, Platt and Sully's Hill, although interesting areas, do not in any sense compare with our other national parks, and would today never qualify as such. The apparent let-down in the standards of national park creation as illustrated by the establishment of the lesser important areas in the Dakotas and in Oklahoma into national parks did not at all reflect the trend in national park standards. For subsequently no other parks of similar caliber have been created. Witness for example Mesa Verde in 1905, Glacier in 1910, and Rocky Mountain National Park in 1915. Until 1916 there was no national park system. Each park and monument was created individually, with no thought of their being a part of a grand system. Neither was there any uniformity in regard to park administration. Each park was a law unto itself.

It was in this middle period, namely in 1906, that national monuments came into existence by the act of June 8. This act, called the antiquities act, gave the President of the United States power to set aside by proclamation any lands owned or controlled by the United States containing "historic landmarks, historic or prehistoric structures, and other objects of historic or scientific interest, as national monuments." The act was fostered by archaeological and scientific groups and others interested primarily in safeguarding the ancient pueblos and cliff dwellings of our Southwest. When passed, the act included the preservation from spoliation and destruction not only of the ancient ruins, but also of other objects of historic or scientific value, natural as well as artificial. Strangely enough, the first national monument to be created was the Devil's Tower, in Wyoming, a geological and topographic feature and not an archaeological ruin. Devil's Tower National Monument was created in 1906.

ORIGIN OF THE NATIONAL PARK SYSTEM AND SERVICE

When the Antiquities Act was passed in 1906 creating national monuments, the secretaries of the interior, agriculture and war departments, under whose jurisdiction the monuments came, were instructed to make uniform rules and regulations governing the monuments. There was, however, at this time, no separate organization charged with the administration of our national park system. In 1907 the administration of the parks was given to the miscellaneous section in the office of the Secretary of the Interior. In 1911, 1912, and 1915 national park conferences were held at Yellowstone, Yosemite and at Berkeley, Cal. These conferences, attended by the park superintendents, met to discuss park administration and had much to do with the bringing about of an improved system of park control. In 1913 the assistant to the Secretary of the Interior was given charge of park administration. The following year a general superintendent and landscape engineer of the national parks was appointed, with headquarters at San Francisco and with supervision over all park superintendents. In 1916 the office of the general superintendent was transferred to Washington and authorization was given for the employment of clerical help and other assistants not to exceed four persons.

The idea of a national park system is closely linked with the Pacific Coast Expositions of 1915. Secretary Lane, of the Department of Interior, saw in the existing national parks neglected opportunities which required business experi-

ence to develop. He, therefore, prevailed upon Mr. Stephen T. Mather, a successful business man of Chicago, to undertake the job of preparing the parks for the great crowds that were anticipated to visit them on their westward journey to the Pacific expositions. As related by Yard, "Mr. Mather's vision embraced a correlated system of superlative scenic areas which should become the familiar playgrounds of the whole American people, a system which, if organized and administered with the efficiency of a great business, should even become, in time, the rendezvous of the sightseers of the world. He foresaw in the national parks a new and great national economic asset" (*26*). Through the educational propaganda directed and supervised by Mr. Robert Sterling Yard, our national parks and monuments were widely advertised. "See America First" became the slogan of those interested in promoting our parks and monuments. Universities, civic associations, railroads and clubs, groups and associations of various kinds helped materially to promote the "See America First" movement. Finally in 1916 Congress established the National Park Service as a bureau of the Department of the Interior, with Mr. Stephen T. Mather as its first director. Its duties were to administer the parks and monuments in accordance with a definite policy.

THE MODERN PERIOD—1916

The creation of the National Park Service ushered in the period of earnest planning and the wonderful development of our whole federal park system. This, as we know it today, is without equal, and serves as a model for similar park systems of other countries. There is no park system anywhere in the world where better park administration is to be had, where the preservation of all wild life, plant or animal, is more keenly guarded, where public appreciation of nature's supreme masterpieces is more cultivated, where greater educational and museum facilities are provided and where more thought is given to the comfort of the visitor and to the ease for travel, and where everything is made available to all the people for all time without practically any direct cost to the visitor, than our own national park service and system.

HOW NATIONAL PARKS AND MONUMENTS ARE CREATED

National parks are created by congress, whereas national monuments are established by presidential executive order. The former are areas, usually of considerable size, set aside to conserve notable examples of typical land forms combined with primitive plant and animal conditions. They are also created for the pleasure of the people. Monuments, on the other hand, are created to preserve areas or objects which are historically, ethnologically, or scientifically important. They are confined by law "to the smallest area compatible with the proper care and management of the object to be protected" (*27*). The creation of our national parks and monuments, however, is much more than the last act performed by a Congress or the executive proclamation of a United States president. Our parks and monuments are created only through the persistent and tireless work of public-minded individuals, people who are willing to sacrifice their time, labor, and money, and even are willing to endure hardship in order that the public might be the benefactor. The following instances will suffice to show what it takes to create our national parks. Again a Kansan plays an important role. William G. Steele was a farmer

boy living in Kansas in 1869. Intrigued by a newspaper account of an Oregon lake having precipice sides five thousand feet deep, young Steele developed an ambition to see this wonderful lake. On moving to Oregon in 1871, Steele made inquiry concerning this unusual lake, and after seven years was able to verify its existence. Two years later (1879) he contacted a man who had actually seen the lake. Determined to see the lake for himself, Steele finally reached it in 1885, only after considerable difficulty. While standing on the rim of what we now know as Crater Lake, the Kansan suggested to his partner, Professor Joseph Le Conte, a noted geologist and teacher, that an effort ought to be made to have the lake set aside by the national government from defacement and private exploitation. Presenting a petition to this effect to President Cleveland, the President promptly withdrew ten townships from settlement pending a bill before congress to create a national park. This congress refused to do on the grounds that the state of Oregon should protect its own lake. For 17 years Steele labored, agitating the project without ceasing in his adopted state of Oregon, where he made speeches summer and winter, and at Washington, which he deluged with letters and circulars. Eventually congress yielded, and on May 22, 1902, Crater Lake National Park was created. Steele's enthusiasm is further demonstrated by the fact that for a number of years he conducted a vigorous campaign to have the lake properly stocked with trout. Years of campaigning resulted in success. He also started to raise money to build a road to the lake. The struggle was a stubborn one, but a winter's campaign in Washington, D. C., netted the desired results. According to Yard (*28*) Mr. Steele was a country school teacher and gold prospector whose only income was his salary as a country school teacher. Steele spent many of his summers talking Crater Lake project to audiences in every part of the state, depending upon his many friends for entertainment and for "lifts" from town to town. Mr. Steele was finally rewarded for his efforts by being appointed the first superintendent of Crater Lake National Park, a position he held until 1920, when he became United States commissioner for the park.

The story of the Grand Canyon National Park is replete with many struggles. This park was created as recently as 1919, the bill being signed by President Woodrow Wilson. It took 33 years of hard work to get this park. As early as 1886, Benjamin Harrison, then United States senator from Indiana, introduced a bill to make the Grand Canyon a national park. The whole nation was for it, but the state of Arizona opposed the bill on the grounds that since the entire project lay in one county, the removal of such a large area (56 x 69 miles) from the tax rolls would materially impoverish the very sparsely settled Coconino county. In 1893, Harrison, then as president of the United States, proclaimed the Grand Canyon area a national forest. Inasmuch as mining and other claims within national forests were permissible by law, the establishment of the area into a national forest did not prevent private exploitation. In 1898 depredations and unlawful seizures of land were reported in the forest. The Land Office was instructed to prepare a new national park bill. A year later the land office reported that the bill could not be drawn until the region had been surveyed. The United States Geological Survey was ordered to make the survey. Five years later, when the survey was completed, the bill was not prepared, for it was discovered that the Atlantic and

Pacific railroad, now the Santa Fe, owned rights in the forests which first had to be eliminated. Becoming alarmed at the inroads of private enterprise, President Theodore Roosevelt, on January 11, 1908, by executive order, proclaimed the Grand Canyon National Monument. In 1910 the American Scenic and Historical Preservation Society proposed a bill to create the Grand Canyon National Park of large size. The United States Geological Survey recommended a much smaller area. President Taft directed Senator Flint to introduce a national park bill. This bill was opposed by grazing interests whose cattle and sheep grazed along both rims of the canyon and whose pasturage would be cut off in the creation of the park. As a result of this opposition, Senator Flint's bill was thrown into the hands of conferees. In 1911 Flint introduced the conferee's bill, but met with defeat because of the opposition developed by private interests. In 1917 another attempt was made to create the park, but failed due to opposition from the state of Arizona. Finally on February 26, 1919, the same bill introduced two years earlier was passed by congress and the Grand Canyon Nationaal Park became an established national park, thus finally overcoming all the frustrations of hunters, trappers, miners, grazing interests, water power companies, concessioners, and political sabotage and the like. It is recorded that "the obstacles to the creation of Grand Canyon National Park were more numerous than those encountered in any other national park" (*29*).

In passing it is interesting to note that opposition to the proposed John Muir-Kings Canyon National Park in California comes at the present time from three opposing groups: (1) a few farmers whose cattle graze in the area, (2) sportsmen, and (3) summer home owners. Also, "It was nearly half a century ago that John Muir started the movement to make the Kings River county a national park" (*30*).

CONSERVATION THE PRICE OF VIGILANCE

In an address entitled "Conservation Cousins—Grazing and Parks," delivered by the Hon. Harold L. Ickes, Secretary of Interior, before the American National Livestock Association on February 18 of this year, Mr. Ickes said, "Opposition to the national parks comes from two sources—from a very few people who want to exploit something that belongs to the public, and from those who have been honestly misled by false arguments" (*31*). To illustrate, recall the story of the creation of the Grand Canyon National Park, and more recently the opposition by farmers, sportsmen, summer home owners and even the regional office of the Forest Service to the creation of the John Muir-Kings Canyon National Park. One would think, however, that after a park or monument had once been established, all further worries concerning those areas would have ceased. But such is not the case. Even today vigorous assaults upon national parks conservation are in evidence. The period between 1920 and 1925 is especially outstanding in this respect and marked a momentous struggle in congress. According to a report by former Director Mather of the National Park Service (*32*), five extensive irrigation power projects proposing to utilize the waters of the Yellowstone lakes and rivers by impounding them within the park itself have been vigorously furthered by Idaho, Montana, and Wyoming interests between 1919 and 1922. One of the projects reached congress and was favorably acted upon by the Senate. How

close was the call for outside interests gaining a foothold in our national park system and how tremendously important eternal vigilance is to the safety of the conservation of our natural areas is well illustrated by the story of our federal water power act. Unfortunately, in December, 1913, an act was passed by Congress which gave the city of San Francisco the right to use certain land in the Yosemite National Park, specifically the Hetch Hetchy Valley, for the construction of a reservoir to supply that city with water and to generate electric power. Although vigorously opposed, San Francisco won out. This act, although specifically restricted to Yosemite Park, provided a precedent for all other parks. On June 10, 1920, President Wilson signed the federal water power act. Before becoming a law, the act was submitted to the National Park Service in a tentative form. As read, it fully protected the parks and monuments from commercial invasion for water power or irrigation purposes. When congress passed the bill, however, and sent it to the president for signature, Mr. R. S. Yard discovered on the very last day of the session that the bill specifically turned the national parks and monuments over to the new Federal Power Commission with authority to grant water power leases within them all and at will. Instant action by the National Parks Association resulted in telegraphing the news to public spirited men and organizations in every part of the country. Before the fall of the gavel which closed the session, the President was swamped with telegrams urging that he withhold signature until the National Parks should be eliminated from the text of the act. On presenting the situation to the President, the Secretary of the Interior, the Hon. John Barton Payne, was able to persuade him from signing the bill. Protests arose immediately from representatives of western states. On the assurance that amendatory legislation would be presented and passed at the next session of Congress excluding the parks and monuments from the scope of the act, President Wilson signed the bill on June 10, 1920. Between June 10, 1920, and March, 1921, when the amendatory legislation was passed, several applications were made to the Federal Power Commission for licenses for water power rights in the Sequoia, Yosemite, and Grand Canyon parks. Fortunately, the commissioners, at the request of the Secretary of the Interior, agreed not to consider applications for licenses within the parks until congress had an opportunity to enact the promised amendatory legislation, which it did in March, 1921. However, when in 1921 congress again restored the national parks to the sole authority of congress, the western power interests insisted that such authority should be limited to parks already in existence. With threats to kill the amendatory legislation if not limited to existing parks and not to jeopardize the pending bill, the act, on the recommendation of the interior department, was passed. As a result, each new national park is subject to the authority of the Federal Power Commission unless its creative act shall have definitely excepted it therefrom (*33*). And still the fight continues and commercialism is defiant. Heed this from the annual report of the Secretary of the Interior for the year ending 1938, by Secretary Ickes. Yellowstone National Park is again threatened with despoliation of its scenic beauty. Bills S. 3925 and H. R. 10469 were introduced at the last session of congress—bills which had for their purpose the diversion of the water of Yellowstone Lake for commercial irrigation purposes and included as part of the scheme the construction of the dam and tunnel within the park area. Naturally, the National Park Service was vigorously opposed to the bill as

were all other conservationists. As pointed out by Secretary Ickes, besides ruining the scenic beauty of the park, the possible disrupting geyser and hot spring activity, breaking faith with the men who, by their vision and generosity, made possible the park's establishment, the bill if passed would establish a precedent which would undoubtedly lead to enormous pressure for similar commercial concessions in other important areas of the federal park system. A somewhat similar case was the proposed irrigation tunnel through Rocky Mountain National Park, a project designed to benefit the beet growers of eastern Colorado. It will be remembered that our own Academy passed a resolution in 1937 as being opposed to this project and went on record to help kill any attempt to commercialize our national parks and monuments. The proposed irrigation tunnel, called the Colorado-Big Thompson project, was finally approved by President Roosevelt on December 21, 1937. However, the new project which is designed to supply supplemental water for 615,000 acres of land on the eastern slope of the continental divide in northeastern Colorado and which will carry the water from the headwaters of Colorado river on the western slope through a 13.1 mile long tunnel to the South Platte drainage area will be constructed entirely beneath the surface and will in no way efface any surface features in Rocky Mountain National Park. Thus it seems that the proponents of power, irrigation, and water supply projects want to get into our parks on the general proposition that the local needs along these lines should outweight all other considerations (*34*). Perhaps the most flagrant case on record is the one that opened Glacier Bay National Monument to prospecting and mining.

Thanks are due to the National Park Service, the National Parks Association, the Emergency Conservation Committee of New York, the large group of innumerable public-spirited men and women, and the conservation-minded clubs, societies, and associations throughout the country for their eternal vigilance in endeavoring to protect our national parks and monuments from spoliation and commercialism. I am happy to say that our own Academy of Science is numbered among this group of conservationists.

WHAT THE SURVEY OF NATIONAL PARKS AND MONUMENTS TEACHES

As stated earlier in this address, this survey of our federal park system was made in direct response to the questions, Is it worthwhile to continue our national monument project? and What does it take to bring about the creation of a national monument? If the story of the national parks and monuments teaches us anything, it is this: In the first place, to have a national monument we must have something worthwhile and outstanding to preserve. Second, we must make our people monument-minded; that is, we must propagandize our efforts. Third, we must never become discouraged and give up hope; in short, we must develop an undefeatable spirit, for it may take many years before our cherished dream may become a reality. Fourth, we must expect to meet opposition to our efforts and be ready to surmount all obstacles. Fifth, we must watch to the very last minute that nothing extraneous is introduced into any measure which would defeat or injure our project, and sixth, should our efforts to create a national or state monument be successful, we must exercise eternal vigilance in order that commercialism and spoliation may forever be ruled out. If I ever was discouraged, this sur-

vey has given me new hope and a faith that eventually we will win out, and that "success crowns effort" and "nil desperandum," class mottoes of my grade and high school days, are, after all, well worthwhile remembering.

THE CONSERVATION PROGRAM OF OTHER STATES

My study of our national parks and monuments and our efforts to preserve the area of concretions near Minneapolis quite naturally led me to wonder what other states were doing to preserve their natural areas. So I wrote 48 letters, addressed them in care of the Department of Conservation, and mailed one to each state, requesting certain data, literature and maps relative to their conservation program. The returns were gratifying, informative, instructive, and of great help in formulating plans for conservation in our own state. Some of the pertinent data are given in table 2.

Time does not permit me to discuss fully state parks and monuments in other states. Suffice it to say that from the reports received in almost every state, certain parks were created primarily to preserve natural scenery, geologic phenomena, native vegetation, wild animal life, archaeological sites and historic spots. This is especially true in Iowa, Wisconsin, Illinois, Minnesota, Oklahoma, Pennsylvania, Michigan, Arkansas, Maryland, and California. Such parks are of course also used as recreational purposes, although in some instances no improvements are made in the park, and the vegetation and animal life are permitted to run wild. Furthermore, most state parks are also game preserves.

The most recent report of the Kansas State Fish, Game, and Forest Division (*35*) shows that there are 20 county state parks under its jurisdiction. All of these parks center around artificially built lakes. Kansas has, according to Mr. John E. Brink, deputy administrator, Works Progress Administration, Topeka, Kan., 60 major lakes (*36*). All of the Kansas parks, as far as I know, were created at places where it was possible to construct artificial lakes because of the presence of springs or streams. Fortunately, certain of the parks, such as the Scott, Clark, Finney, and Woodson County state parks, are also geologically and scenically interesting. Under our present setup, I am doubtful, however, whether any of the native vegetation can long survive, especially after the parks are more and more developed as purely recreational centers. The Meade County state park is the only one that I know of as having been purchased and which is only partially developed in order that the visitor might obtain a fleeting glimpse of the Kansas that was. While it is true that certain states are much more endowed with natural areas than is Kansas, nevertheless it is also true that Kansas has not taken advantage of the areas that she has. If she had, one would hardly expect to read such accounts as the following one by an eastern traveler published in an eastern newspaper:

"You enter Colorado through Kansas, and one of the first towns in Kansas is Olathe, which produced Buddy Rogers. Olathe is an Indian name meaning beautiful, so you can make up your own jokes. . . . At Lawrence, founded by and named after Bostonian Amos Lawrence, Massachusetts merchant, is one of the rarest of factories—a horse collar factory that supplies most of the midwest farmers. . . . Topeka, you learn, is an Indian name for 'a good place to dig potatoes.' Wichita sends out most of the whiskbrooms you use in your home or office. . . . Dodge City, was a noted shipping point on the old Texas to Montana cattle trail . . . In 1884, the old settlers

TABLE 2.—Number of State and National Parks and Monuments Reported by Conservation Commissions, March, 1938

State.	State parks.	National.		State.	State parks.	National.	
		Parks.	Monuments.			Parks.	Monuments.
Alabama	15			Nebraska			2
Arizona		1	15	Nevada	5		2
Arkansas	10	1		New Hampshire			
California	70	4	8	New Jersey	12		
Colorado		2	7	New Mexico		1	8
Connecticut	51			New York	70		2
Delaware	4			North Carolina	5	1	
Florida	*		3	North Dakota	*		1
Georgia	9		2	Ohio	2		2
Idaho	1	1	1	Oklahoma	8	1	
Illinois	24			Oregon	130	1	1
Indiana	*			Pennsylvania	100		
Iowa	75			Rhode Island	*		
Kansas	20			South Carolina	15		1
Kentucky	19	2		South Dakota	1	1	3
Louisiana	*			Tennessee	17	1	1
Maine	20	1		Texas	26		
Maryland	4	1		Utah		2	9
Massachusetts	*			Vermont	38		
Michigan	58			Virginia	6	1	1
Minnesota	45		1	Washington	52	2	
Mississippi	10		1	West Virginia	17		
Missouri	28			Wisconsin	22		
Montana	*	2	1	Wyoming	2	2	3

* No report.

NOTE: In addition to the above, there are national and state forests, game preserves, national cemeteries, military parks, historical sites, recreational areas, battlefield sites and others.

will tell you, 8,000,000 cattle passed through, with 4,000 cowboys herding them along. Then Kansas enacted a quarantine against Texas cattle and Dodge City no longer heard the mooing of the herds" (*37*).

Who, after all, is responsible for such advertising of Kansas? Kansans, of course. People usually see what is pointed out to them. Are we bidding for travel through our state? Then it is necessary to dispel, first of all, the concept that so many people have, namely that our state is a vast, featureless, monotonous, treeless hot plain, where tornadoes and dust storms are common occurrences.

Governor Ratner has recently signed the industrial bill. This bill, as you know, carries with it an appropriation of $62,500 a year for the next biennium

and is designed to encourage industrial development in our state. To be sure, industry is finally located on the basis of abundant and cheap natural or raw resources and good potential markets. However, climate and topography are contributing factors in bringing about industrial development and may be the ones that are instrumental in determining whether an area will be investigated or not. Therefore, it behooves Kansas to develop her topographic and geologic features of unusual merit and proclaim them to all the world. It is interesting to note in this connection what the director of the Bureau of Inland Lakes and Parks of Ohio has to say in regard to people going elsewhere: "The annual migration of the Ohio pleasure seeker is because of two things: One is lack of information as to what Ohio has to offer, and the second, the more important, lack of development of these natural resources" (*38*).

Judging from the number of people who visit the state parks and monuments in other states (table 3) state parks and monuments are a distinct economic asset. In Iowa, for example, 2,670,000 people visited the Iowa owned parks in 1938. This number is greater than the total population of that state. Other notable examples reported by various conservation commissions are listed in the above table. Our own Leavenworth County state park drew 20,000 people on the opening day, and likewise, 10,000 visitors crowded into Neosho County state park on its opening day. It goes without

TABLE 3.—Attendance of Park Visitors Reported by Conservation Commissions

State.	Visitors.	Year.
New York[1]	26,094,000	1937
Michigan	7,901,458	1938
Iowa	2,670,000	1938
Connecticut	2,480,000	1936
South Carolina	478,617	1937
West Virginia	315,000	1938
Virginia	218,000	1937
Arkansas	212,914	1938
Maryland	180,000	1937
Maine	177,000	1938
Kansas[2]	48,706	1938

1. Visitors reported in 5 out of the 11 regional park areas.
2. Reported for 6 parks for the period of one month.

saying that considerable money is spent by these park visitors in coming to, going from, and while staying at the park. To illustrate, the United States Travel Bureau estimated that a minimum of $15 per person was spent in Arkansas by every out-of-state park visitor last year. With a total of 26,444 out-of-state visitors, the Arkansas state parks netted an income to the state of $396,660. Add to this $1 per person for each of the 155,652 home-state park visitors, the total net contribution to the state of Arkansas in 1938 through its state park system amounted to $552,312.

CONCLUSIONS AND RECOMMENDATIONS

Information gathered from all of the state conservation commissions in the United States reveals the fact that practically every state recognizes the value of state parks from at least three view points; namely, recreation, conservation, and economics. Most of the state parks center around scenic, geologic, or forested areas, and besides serving as game refuges, give protection to all phases of natural phenomena, both physical and biologic. The survey shows that most parks are designed for recreational purposes; that is, recreation used in its broader sense. Visitors, too, are subject to definite restrictions such as camping only in designated spots, prohibited from defacing and destroying natural phenomena, plucking and uprooting of wild flowers and cutting down or digging up and carrying away trees. Commercialism of any kind is also not tolerated in any of the state-owned and controlled parks.

I believe Kansas has everything to gain and nothing to lose in developing a state park system. In the first place, I would like to see a well planned park system, with the park areas well selected in all parts of the state, and all connected by good roads and linked up with our transcontinental highways. In the main, the parks would be our great out-of-doors recreational centers. In selecting their sites, first consideration should be given to natural or scenic settings of the proposed parks.

Second, certainly all unusual topographic and geologic features, such as Rock City, near Minneapolis in Ottawa county, monument rock, the sphynx, and castle rock in Gove county, etc., should be included in our park system. These areas should be preserved for all times and for all the people and should be developed primarily for scientific and educational purposes rather than for recreation. Such areas might propertly be designated as state monuments in order to differentiate them from the more purely recreational types of parks.

Third, the state parks and monuments should also be described adequately by competent people in booklet form, published and then widely distributed. The preparation of the manuscripts might well be prepared by members of our Academy.

In the fourth place, I should like to recommend that all of our parks also serve an educational purpose; that is, serve as an outdoor classroom or museum. This could be done easily by properly labeling trees, shrubs, and other types of vegetation, as well as all rock formations. We have already been assured coöperation by the State Fish and Game Commission on this project.

Fifth, since our present state parks are sponsored and maintained by money derived from the sale of hunting and fishing licenses, the State Fish and Game Commission feels that it is an injustice to those who purchase the licenses to open up the parks to the general public, most of whom pay no fee for their recreational use of the parks. The Commission suggests two alternatives to remedy the situation: (1) to charge a recreational fee for all who use the parks, and (2) to divorce those areas from the State Fish and Game Commission, appropriating money for their maintenance and open them to the general public (*39*). I should like to propose that the Academy coöperate with the Commission in studying this problem and help support any project which will be of greatest mutual advantage to our park system, the general public, and the State Fish and Game Commission.

Sixth, in a report on recreational resources prepared by the National Park Service for the National Resources Committee (*40*) is found the following item, article 18, under the general caption, "The following general areas, largely in private ownership, contain features suitable for inclusion in the national park system." Article 18, "An area, or areas, of considerable extent representative of the great plains in Nebraska, Wyoming, Colorado, or Kansas." All of the states mentioned except Kansas possess either a national park or two, or else several national monuments. Since the western one-third of Kansas is typical great plains country, I should like to propose that the Academy agitate for the location of a national area representative of the great plains in western Kansas.

Seventh and last, I recommend that the Academy coöperate with all conservationists, national, state or independent, in helping to protect our national parks and monuments from spoliation and exploitation.

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The Effect of Environment on Wheat Quality: A Résumé[1]

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The relation between environment and quality of wheat has always interested scientists, but today the question is particularly interesting because many countries, especially those in Europe which naturally produce low-quality wheats, have embarked on a policy of self sufficiency, and are endeavoring to grow within their own borders sufficient wheat to make them independent of imports. The question is: Can they, by any means whatsoever, materially improve the quality of their native wheats sufficiently to dispense with the high strength wheats of this continent? In attempting to arrive at a satisfactory answer it is necessary to consider the relations between climate, weather, soil, variety and quality. If the climate-weather-soil combination, which is often referred to as the environment, is the predominant influence, not much change in the situation need be anticipated, because the climate and weather are not amenable to control, and any attempts to modify the soil are in the long run of relatively small importance, as the soil is likely the result of the climate in which it is found. If on the other hand variety is found to play an important part in determining quality, there is a likelihood that the general level of quality in Europe may be raised. It would not have to be raised a great deal to effect considerable reduction in the importation of strong blending wheats. Whatever the answer may be, it seems certain that very strenuous efforts to raise the quality of domestic wheat in Europe will be made if the present isolationist policies are continued. If that objective fails there remains the alternative of altering the quality of bread by means of government regulations affecting the milling of wheat.

It is manifestly beyond the scope of this paper to review in detail the earlier work upon which our current ideas of environmental effect are based. Reviews and summaries are to be found in a number of publications, among which might be mentioned those of Hall (1905), Lyon (1910), Bailey (1925), Alsberg and Griffing (1934), and Swanson (1938).

The purpose of this paper is to review the more recent work, particularly that which deals with the effect of weather on wheat quality.

The observation that high-quality wheat grows in areas of scanty rainfall and relatively high temperatures has led to the broad conclusion that climate is the principal factor influencing quality. Continental climates, such as found in Hungary, southwestern Russia, western Canada and mid-western United States, on the whole are favorable to the production of high-protein, hard, flinty wheat, while insular climates in general favor the production of low-protein, starchy, plump, soft-textured wheats.

The first record of any systematic attempt to discover the relationship between climate and wheat quality appears to be that of Lawes and Gilbert (1857), who conducted a series of experiments from which they concluded that a long ripening period after heading resulted in plump wheat of low

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Presented at the Weather Crops Seminar. October, 1938, Wichita, Kan.

nitrogen content, whereas a short ripening period gave the reverse result. Between 1857 and 1905 numerous scientists published observations which confirmed the earlier conclusions of Lawes and Gilbert. This work was summarized by Hall (1905), who concluded that soil has comparatively small effect, while the effect of climate is large, though not large enough to explain all the facts.

The work in this field was again summarized in 1910 by Lyon, who concluded that the production of hard, glutinous wheat resulted from (*a*) abundance of nitrogen in the soil, (*b*) hot weather early in the growing season to promote nitrification and to favor a large absorption by the plant, (*c*) light rainfall and large evaporation which concentrates the nitrates in the upper portion of the soil, and (*d*) short ripening period which tends to lessen the transference of starch-forming materials to the kernel.

The decade from 1910 to 1920 witnessed great activity in the study of factors influencing wheat quality. Shaw and Walters in California, Headden in Colorado, Thatcher in Washington State, Widtsoe in Utah, Stockham in North Dakota, Snyder in Minnesota, Ames in Ohio, LeClerc and associates for the United States Department of Agriculture, Shutt in Canada, and many others published reports of investigations on the relationship of wheat composition to climate, soil, fertilizers, irrigation, and variety. All the work on this subject up to 1924 has been carefully reviewed by Bailey (1925), who made the following summary:

(1) Cool summers with high rainfall and a relatively long growth produce wheat of low protein content, while hot, dry summers result in the production of wheat having a high percentage of protein. The rate of starch deposition in the kernel is influenced by the rainfall during the filling period.

(2) The protein content of the seed has little, if any influence on the protein content of the crop.

(3) The protein content of the grain varies inversely with the quantity of irrigation water applied.

(4) Soil texture appears to be responsible for greater variations in protein of wheat than soil composition within the limits of soil composition encountered in usual agricultural practice. Soils capable of retaining much moisture in a form available to the plant produce wheat low in protein and vice versa.

(5) Fertilizers exert influences on protein content of wheat. Nitrogenous fertilizers, particularly inorganic forms, usually raise the protein content of wheat, especially if applied at blossoming time. Phosphates tend to lower the protein. Potash has no significant effect, nor have "complete" fertilizers unless the proportion of phosphate is high.

(6) Finally, climatic conditions are responsible for greater variations in the composition of wheat than are other factors, with the possible exception of irrigation.

Whether the younger agronomists in America and elsewhere accepted these results as conclusive, or merely turned their attention to more pressing problems, the fact remains that when Alsberg and Griffing (1934) made another review of this subject, they were able to add few conclusions to those enumerated by Bailey in 1925. They did, however, stress the importance of length of the post-floral period as a major determinant of protein content of the wheat. This lull in activity in connection with this problem might be interpreted as meaning that scientists were fairly content with the theories previously ad-

vanced. However, there are sufficient exceptions to those generalized conclusions to keep the question open, and to provoke further investigations into the factors that influence the quality of wheat.

The exceptions have in general been associated with the effects of the chemical composition of the soil. Bogdan (1900), studying the alkali soils of Russia, found that an increase of the percentage of soluble salts in the soil was associated with an increase in the protein content of the wheat grown on it. He regarded this as one of the reasons for the high protein content of wheat grown in eastern and southeastern Russia.

Shutt (1908) reported the results of an experiment in which wheat was grown on two contiguous soils, one freshly broken from cleared scrub land, the other, one that had been under cultivation for ten years. The cultivated land produced wheat of 13.5% protein, while the new land produced wheat of 10.0% protein. The most important chemical differences in the two soils were that the newly broken soil was higher in organic matter, nitrogen, and lime, and at all periods during the growing season it held much more water than the older soil.

Headden (1915) found that yellowberry could be prevented by the application of nitrates and intensified by the application of potassium salts. He concluded that a high P to N ratio in the soil is responsible for yellowberry. This, however, is not the complete answer to that problem, because Headden's own data (1918) showed that addition of K to soils affected no significant change in the nitrogen content of wheats grown thereon.

McCalla (1934) showed that shortage of potassium, while not affecting the total nitrogen content of the wheat, does affect the quality by lowering the ratio of gluten nitrogen to nongluten nitrogen in the grain. He interpreted this as meaning that while the total nitrogen was unchanged, the quality was lower. His data were obtained with wheat grown in cultures, and whether similar results could be replicated in the field is a question that has not been answered yet.

Studies conducted at the University of Saskatchewan during the years 1927 to 1937, by the author, indicate that soils exert a marked effect on the composition of wheat. This applies particularly in the case of certain very distinctive types of soil, the most outstanding of which are (1) the alkali or saline, and (2) the leached or podsolized soils. Both these types tend to produce low-protein wheat. Baking tests have shown that wheats grown on podsolized soils are distinctly lower in quality than those grown on normal soils in the same area, under the same or very nearly the same weather conditions. While the data for saline soils are by no means as conclusive as those for podsolized soils, they indicate also lowered quality, a result contrary to that reported by Bogdan. This may be explained by the fact that most of the saline soils in western Canada are poorly drained, their high salt content resulting from this circumstance. The poor drainage would result, in most seasons, in imperviousness which would tend to lower the nitrogen content of the wheat. However that may be, a careful study of a large number of small areas within the province of Saskatchewan has shown that where the soil is uniform in type the protein of the wheat varies over a relatively narrow range, while in those areas showing great soil heterogeneity, the variations of protein content are large. It is not uncommon to find wheat of one variety grown in a small area on soil of the same type of cultivation showing a range in protein

content of 10 to 15 percent or more. Notwithstanding the fact that the weather may vary greatly within such areas, a large number of similar observations seem to justify the conclusion stated above.

Aamodt and McCalla (1935) showed that wheats grown on grey bush soil of Alberta, in addition to being low in protein content, were qualitatively different from those grown on normal black soils, inasmuch as the flour milled from them was very much poorer in keeping quality. In a continuation of this study, Woodford and McCalla (1936) reported that different varieties of wheat, when grown on grey bush soils, exhibit marked differences in respect to the rate at which their flours deteriorate on storage. They suggested that the nitrogen, phosphorus and sulfur balance in the wheat may be important in determining the keeping quality of flour.

The various investigations cited indicate that the soil composition may play a more prominent role in determining quality than has been thought heretofore. While admittedly climate in the broad sense plays the predominant role in determining wheat quality, there is little doubt that the wide differences to be found in wheats of the same variety grown under the same weather conditions must be accounted for on the basis of the soil texture and composition.

Recently Hopkins (1935a) has reported the results of a very comprehensive study of climatic factors in relation to nitrogen content of wheat. He concluded that by far the greatest effect on nitrogen content of wheat is caused by the rainfall in the early part of the growing season, especially in May and June, before blossoming. He made a statistical study of Shutt's data on Marquis wheat grown at five western Canadian experimental farms over the period 1915 to 1932. Considering the effect of rainfall on nitrogen content and on yield per acre, the data shown in Table I indicate clearly that the greatest effect on nitrogen content is attributable to rainfall in the early part of the growing season, a conclusion contrary to the generally accepted belief, that it is the rainfall which occurs after translocation has begun, that is the most important factor in respect to protein of wheat.

TABLE I.—Regression coefficients of nitrogen and of grain yield on rainfall by months. Hopkins' data (1935a).

Regression coefficient per additional inch of rainfall.	Nitrogen, percent.	Grain yield, pounds per acre.
May	—.0804	160
June	—.0586	167
July	—.0234	175
August	.0028	—16

He also studied the preseasonal precipitation to see if there might be some indirect effect through the initial supply of soil moisture present before the crop was seeded, but the results were not significant, and although there was some indication of a relationship, no definite conclusions could be drawn.

The general conclusions agree with those of Russell and Bishop (1933), who in studying the influence of weather conditions on the nitrogen content of barley grown in England, found that the major effect of rainfall was attribu-

table to that which occurred in the first half of the growing season, the effect of temperature at all times appearing to be slight. They suggested that excessive spring rains may leach out nitrates, which would otherwise remain to be utilized by the plant at a later stage of development. While this may be the explanation of their results, it seems unlikely that it would apply to the semi-arid conditions of Western Canada. Excessive rainfall may indeed carry the available nitrates to somewhat lower levels and by lowering the temperature of the soil, temporarily retard the rate of nitrification, but Hopkins believes that the principal effect is produced in another way. It was pointed out by Smith (1925), that rainfall and extent of tillering are highly correlated. He reported a value of +0.92. As a result of this proliferation the supply of available nitrogen must be distributed amongst an increased number of culms and the total leaf area devoted to the production of carbohydrates would also be augmented, both circumstances tending thus toward a diminished proportion of nitrogen in the resulting grain. The insignificant effect of later rainfall may be due in part to the fact that (1) most of the plant nutrients derived from the soil are taken up before blossom; (2) as pointed out by Russell and Bishop (1933), the ratio of carbohydrates to nitrogen in the translocating material is, even in an unfavorable season, so high that very large additional amounts of the former would have to be produced by the plant in order to affect appreciably the composition of the grain. Variation due to soil differences between the plots employed in different seasons may also have obscured the significance of real, though less pronounced, weather effects.

The apparently meager effect of temperature during the latter stages of development is perhaps surprising, for quite apart from any possible influence of desiccation on the proportionate translocation of carbohydrate and protein, higher temperatures might be expected to affect the ratio of nitrogenous to carbonaceous material in the developing grain by increasing the rate of respiration. Respiration is known to increase in an approximately exponential manner with temperature up to the lethal point, so that a difference of one degree has a greater effect at high than at low temperatures; the use of a linear average may therefore have failed to reveal the true effect of relatively short periods of very hot weather. From the point of view of the desiccation theory the inadequacy of temperature records, confined to daily maxima and minima, as an indication of the actual conditions, especially those resulting from hot, dry winds, should not be overlooked. The systematic compilation of evaporation measurements at agricultural experiment stations would undoubtedly provide data of considerable value for use in future agricultural meteorological studies.

In a second paper Hopkins (1935b), reported further the effect of temperature on the nitrogen content and yield of wheat, using the same data described heretofore. In this study, in place of using the temperatures as recorded, he calculated first the temperature coefficients for successive three-week periods, beginning July 1st and carrying through to September 1st.[2] These daily

2. The temperature coefficient was calculated as follows: Assuming the temperature quotient of respiration of developing wheat kernels to be 2, since the actual value is not known, the respiration at any temperature t°F, will be in the proportion of $2^{\frac{t-32}{18}}$ to that at 0°C. Substitution of the maximum and minimum temperatures recorded on any day in this expression yielded maximum and minimum temperature coefficients which were summed to give a daily temperature coefficient.

temperature coefficients for the last two three-week periods, after eliminating the effect of May and June rainfall, was +.33, a moderate but significant value. In view of the fact that the straight temperature averages did not show any significant correlation, these results appear to support the view of McGinnis and Taylor (1932) that differences in the amount of respiration of the maturing kernel might modify appreciably the percentage nitrogen content of wheat, although they could not be expected to account for all of the observed variation.

In this study, furthermore, Hopkins showed that a positive correlation of 0.74 existed between height of the crop and yield of grain, and a negative correlation of 0.50 between height and nitrogen content. The partial correlation between nitrogen content and yield after eliminating variations in both associated with height, was negligible, —0.07, suggesting that reductions in yield due to restriction of the later stages of translocation did not result in significant modification of the nitrogen content of the grain.

Thus this work appears to weaken the theory that seasonal variations in moisture supply during the later weeks of development and ripening of the kernel, are of prime importance in determining the composition of the grain in respect to nitrogen content.

Shutt and Hamilton (1934), in a paper based on data collected by the senior author (Shutt), over a period of 20 years, concluded that the scanty precipitation and high temperature during the latter weeks of development and ripening of the kernel, by drying out the soil, constitute the chief environmental factor conducive to high protein wheat. However, it should be pointed out that they based their study largely on data obtained on samples grown in widely different parts of the country, namely, Charlottetown, P. E. I., Kentville, N. S., Scott, Sask., and Ivermere, B. C. They were thus studying the effect of climate rather than the effect of weather, while Hopkins, limiting his data to those obtained in one climatic zone was actually getting at the weather factors.

Swanson (1924), pointed out that although high yield is usually associated with low protein, there is no reason, if the available nitrate supply is adequate, why both high yield and high protein may not be obtained. Malloch and Newton (1934), studied the variation of yield and protein in small areas by collecting fifty 18-foot single row samples from a field of one pure line variety. This was done in two consecutive years. They got correlations of -.68 and -.42 between yield and protein for the two years respectively. As no measurements of height were made in this investigation, it is not possible to say whether or not these results disagree with the conclusions of Hopkins.

The most recent work on this phase of the subject is that of Hopkins (1938). In a greenhouse study of Marquis wheat, he grew six sets of plants using soil moistures of 15, 20, and 25 percent, with two sets of diurnal temperature ranges namely, 45° to 70° F. and 55° to 80° F. Samples taken at the early dough stage showed higher nitrogen with higher tempertature; at the late dough stage there were significant differences attributable to the moisture of the soil; but at maturity all six treatments showed the same nitrogen content. Considerably greater yields were obtained with the highest moisture level. Hopkins explains these facts by applying the theory of McGinnis and Taylor (1932), already mentioned, that respiration in the young kernel may exert an important effect on the protein content by using up carbohydrates. The longer period of de-

velopment in the soil of highest moisture compensated for the slower rate of respiration. The condition of having the soil moisture constant right up to final maturity is seldom encountered in nature. Nevertheless, one important conclusion may be derived from this work, namely, the length of the postfloral period cannot be taken alone; one must also record the moisture of the soil and the temperature during the period.

Thus the major considerations have been climate, weather and soil. Some consideration ought to be given to variety. This is an important question at the present time in those countries that are either seeking to become self-sufficient, or to compete more vigorously in the European market. Relative to this, Alsberg and Griffing (1934) state that, "Where the plant breeder has been willing to sacrifice something in yield . . . it has already been possible to produce wheat of fair though not of highest quality and with fairly good yields in countries where wheat has heretofore been always weak." This has been accomplished in parts of Europe, in the Argentine, and in Australia, to some extent.

There is little doubt that among the spring wheat varieties there are some that consistently produce higher protein than others. Larmour (1930) showed that Garnet was lower and Reward higher than Marquis, and these observations have been amply confirmed since then. In all comparisons of varieties with regard to protein content, the yields need to be considered lest what appears to be a varietal difference may be due merely to insufficient available nitrates in the soil. The three varieties mentioned above have been grown for many years in comparative trials at the many Dominion Experimental Farms in Western Canada, and a great deal of data on both yield and protein is available. The variations in yield are not sufficiently great to account for the differences in protein content of these varieties. It is true that in the northern part of the area, where the rainfall is higher with consequent higher yields, the differences between these varieties are greatest, but the differences still persist in the southern areas, where yields are low and where the available nitrates in the soil cannot be considered a limiting factor in protein production.

Doubtlessly there is a fairly close relationship between yield and protein, especially in regions where the yield may be high or where there is likely to be some shortage of nitrates in the soil.

Recently several very interesting studies dealing with variety have been published. Waldron (1933), in a study of 25 varieties, reported a correlation of —.556 between yield and protein. This indicates that capacity to yield and to produce high protein are not generally found in the one variety. However, these data can be regarded only as an indication of relationship, as the magnitude of the correlation coefficient leaves approximately 70 percent of the variability in protein unaccounted for by yield. Neatby and McCalla (1938) made a statistical analysis of much of the data available from the varietal trials of the rust-resistant hybrids grown in Canada in recent years, as well as some of the data available from the United States Department of Agriculture. They concluded that high yielding varieties of wheat and barley have a marked tendency to be constitutionally low in protein. They regard as doubtful that maximum possible yield can be combined with maximum possible protein in breeding wheats. It was suggested that "high-yield genes" may indirectly depress the protein content, just as environmental fac-

tors which promote high yield may do so at the expense of protein. They believe that in any wheat breeding plan some sacrifice of yield must be made to get the highest protein and vice versa. Occasionally a variety combines both high yield and high protein, as in the case of Thacher, but such occurrences are the exception.

A somewhat different result was reported by Whiteside (1936), who also experimented with pure lines of wheat. Using Fisher's method of variance analysis, to separate out the effect due to environment, he found that yield and protein are not significantly correlated among varieties. He also obtained evidence that some varieties are consistently higher or lower in proteim than others.

SUMMARY

Without enumerating again all the older views concerning the relations between climate, soil, variety and quality, it may be useful to point out what the recent work in this field has contributed. Probably the most important contribution is to seasonal or weather effects. It appears to be established that the rainfall in May and June* is much more important in determining protein content than the rainfall in the latter part of the growing period, when seasonal effects are being considered. It is also evident that the length alone of the post-floral period is not enough; the temperature and the soil moisture must both be considered along with the time.

It seems likely that yielding and protein-forming capacities are inversely related, although this question cannot be accepted as finally settled. It is applicable within single pure varieties. Opinion is divided as to its applicability among different varieties.

Increasing emphasis may be expected on the respiration rate of the developing kernel, and on the early season growth of the plant. The resumé here given points to the need for more intensive study of the physiological processes of the maturing seed, considered with more complete data on the weather and the soil.

It should be pointed out that in most of these studies the assumption has been tacitly accepted that protein content is an adequate measure of quality. The poorer keeping quality of flours, from wheat grown on grey soils, indicates that this view ought to be modified.*

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Effects of Soil Amendments upon Bacterial Populations Associated with Roots of Wheat[1]

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The greater concentration of microörganisms in the immediate vicinity of plant roots has been emphasized recently by Starkey (*1, 2*) and by Thom and Humfeld (*3*). Summarizing for the plants studied, Starkey (*2*) found 45.3 times as many bacteria on root surfaces as in soil close to plant roots, and concluded that sufficient organic substances come from roots to favor greatly the development of microörganisms on their surface. Thom and Humfeld (*3*) also reported increased number of microörganisms on root surfaces; they observed variations of numbers associated with roots of corn plants of the same age and grown under identical conditions except for variations in the origin, texture and hydrogen ion concentrations of the soils employed, and they noted that larger numbers of bacteria were associated with roots of tobacco known to be infected with root rot or to have been grown in heavily infested soil than with roots grown in the absence of the disease. Starkey (*4*) found differences in the numbers of organisms associated with roots at different stages of plant growth.

Although these observations indicate the effects of age of plant, of soil type, and of the presence of disease, the extent to which numbers of microorganisms upon plant roots vary because of soil treatment is still generally unknown. The successes of Fellows (*5*) and of King (*6*) in controlling root rots of wheat and of cotton by organic matter amendments, and their assumption that microbiological factors are of importance in such control, have in part prompted the present study.

METHODS AND MATERIALS

A heavy loam soil approximately neutral in reaction and with a moisture holding capacity of 49 percent was obtained from a field near Delavan, Kan. The field area was naturally infested with the take-all fungus, *Ophiobolus graminis* Sacc. This soil was employed in the greenhouse under the following conditions: (1) untreated soil; (2) soil plus one part in six by volume of chopped green alfalfa hay; (3) soil plus one part in six by volume of chicken manure; and (4) steam-sterilized, and therefore *Ophiobolus*-free, soil. Soils potted under such conditions were immediately planted to wheat, and soil and root samples were collected for microbiological studies at different periods thereafter.

In the collection of root samples, the entire volume of soil in a container was removed; careful shaking was then employed to obtain the root system as nearly free of soil as possible. The root systems thus collected were sus-

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pended in nine times their own weight of sterile water and shaken for ten minutes with glass beads, and subsequent dilutions as necessary were made in order to obtain concentrations of microörganisms suitable for plating. For soil, samples were collected from soil remaining after removal of roots, or from undisturbed greenhouse containers by means of a large cork borer. Gross samples were sieved and mixed thoroughly before ten-gram portions were removed from each for preparation of the dilution series customarily employed for plating.

Quantitative counts of total bacteria were made by the plate method; egg-albumin agar was employed. Plates were incubated at 28° C. for from eight to ten days. Spores of aerobic bacilli were enumerated on nutrient beef agar; the inocula for plates with this medium were pasteurized at 80° C. for ten minutes. For most samples, actinomyces and filamentous fungi were determined also; for these, glycerol-nitrate soil extract agar and acid dextrose-nitrate agar, respectively, were employed.

OBSERVATIONS

Chicken-manured, alfalfa-treated and untreated soils, established in 16-inch unglazed pots for the purpose of determining the effects of various soil conditions upon the bacterial populations in such soils cropped to wheat, were sampled on the 3d, 8th, 14th, 24th, 43d and 60th days. Soil bacterial populations in the treated soils compared to untreated soil populations are shown in table I.

TABLE I.—Comparative bacterial populations in greenhouse soils

Soil Condition.	Number of days following application of treatment.					
	3	8	14	24	43	60
Chicken-manured	49.5[2]	27.7	13.8	16.8	7.7	8.2
Alfalfa-treated	22.6	4.9	1.9	2.1	2.3	4.3
Untreated	1.0	1.0	1.0	1.0	1.0	1.0

2. Bacterial populations in treated soils expressed as multiples of untreated soil populations, considered as unity, on corresponding dates.

For total bacterial populations, the differences between treated soils and untreated soil, as well as the differences between chicken-manure and chopped alfalfa treatments, are obvious.

In order to determine the effects of these soil conditions upon numbers of microörganisms associated with roots of wheat plants, 36 unglazed 6-inch pots, providing 12 replicates each for alfalfa-treated, manured and untreated soils were used. Allowing an initial growth period of three weeks so that sufficient root material could be obtained for study, samples were collected from each soil condition at weekly intervals. Comparative bacterial populations associated with roots of wheat grown in these soils are shown in Table II.

After seven weeks, there was severe damage by take-all in untreated soil; weights of roots collected from untreated, manured and alfalfa-treated soils at 50 days were 8.1, 9.2 and 10.0 grams, respectively; at 64 days, 4, 16 and 15 grams, respectively. Similar differences became apparent in weights of green

TABLE II.—Comparative bacterial populations associated with wheat roots following amendments

Soil Condition.	Age of wheat (in days) at time of sampling.					
	22	29	36	43	50	64
Chicken-manured	1.44[3]	0.67	2.94	1.02	1.32	7.57
Alfalfa-treated	1.58	0.62	1.71	1.04	2.36	4.49
Untreated	1.00	1.00	1.00	1.00	1.00	1.00

3. Root micropopulations following treatments are expressed as multiples of root micropopulations in untreated soil, considered as unity, for corresponding dates of sampling.

tops and average heights of plants. Although after 50 days, significant differences in root micropopulations under different soil conditions were noted, because of variations in plant response and the appearance of disease in untreated soil, such differences are not considered at this time. Some observations on wheat 60 days of age or older were made in the following experimental series with layered soils.

Chicken-manured, steam-sterilized and untreated soils were established in horizontal layers four inches deep, so that each soil was represented once in each of 36 containers. Six replicates of each of the six possible combinations in position were used (Table III shows the various possible combinations of layering). Wheat planted in the top layer subsequently developed roots penetrating all three layers. To permit sampling, wooden boxes eight inches square and fourteen inches deep, with pieces of hail screen (one-fourth inch mesh) to mark the boundaries of adjacent layers, were employed. In sampling, one side of each box was removed and root and soil samples were collected from the various layers.

These three soil conditions layered in single containers retained their characteristic bacterial populations, regardless of position. Relationships between soil populations and total bacterial numbers associated with roots of wheat occurring in the various soil layers are shown in table III. The numbers of spores of aerobic bacilli in variously treated soils, and the numbers associated with segments of wheat roots grown therein, are also shown in table III. For this group agreements between soil and root micropopulations are readily apparent; similar relationships were irregularly noted for the root and soil micropopulations of actinomyces and filamentous fungi.

The lack of close agreements between soil and root bacterial total counts, and in contrast, the agreements between the soil and root populations of certain minor groups, as the aerobic spore-formers, indicated that although the major portion of bacteria on root surfaces were intimately associated with and dependent upon those surfaces, the numbers of particular groups enumerated for root surfaces were determined largely by the numbers of those same groups in the soil. It had become evident that at lower soil moisture contents, root samples were more readily obtained relatively free of adhering soil. Accordingly, a series of six containers was established with untreated soil and young plants from field wheat were transplanted thereto. After four weeks of growth, these pots were watered unevenly, so that at five weeks, moisture contents ranged from 12 percent to 24.5 percent. In the collection of root systems from these containers at five weeks, efforts were made to obtain roots as free of

TABLE III.—Bacterial populations associated with wheat root segments in differently treated soil layers.

Container.	Age of wheat, days.	Soil layer.	Total bacteria.[4] Soil.	Total bacteria.[4] Roots.	Aerobic spores Soil.	Aerobic spores Roots.
a	62	Untreated[5]	104 × 10⁶	150 × 10⁷	67 × 10⁵	47 × 10⁵
		Steamed	605 "	140 "	145 "	177 "
		Manured	1,340 "	160 "	892 "	873 "
b	62	Untreated	89 "	105 "	79 "	57 "
		Manured	865 "	171 "	616 "	840 "
		Steamed	479 "	48 "	55 "	97 "
c	62	Manured	1,608 "	240 "	710 "	580 "
		Untreated	41 "	144 "	39 "	46 "
		Steamed	403 "	80 "	76 "	53 "
d	88	Manured	562 "	193 "	663 "	596 "
		Steamed	223 "	163 "	223 "	69 "
		Untreated	122 "	68 "	59 "	54 "
e	88	Steamed	246 "	161 "	136 "	91 "
		Untreated	135 "	147 "	28 "	64 "
		Manured	1,219 "	216 "	450 "	347 "
f	88	Steamed	506 "	175 "	61 "	26 "
		Manured	1,088 "	168 "	755 "	580 "
		Untreated	75 "	106 "	68 "	50 "
g	88	Untreated	238 "	166 "	74 "	110 "
		Steamed	354 "	115 "	173 "	223 "
		Manured	905 "	80 "	545 "	700 "
h	88	Untreated	144 "	194 "	221 "	86 "
		Manured	1,475 "	183 "	775 "	690 "
		Steamed	368 "	150 "	333 "	97 "
i	124	Manured	360 "	221 "	268 "	240 "
		Steamed	176 "	150 "	36 "	21 "
		Untreated	54 "	102 "	55 "	31 "
j	124	Steamed	189 "	294 "	42 "	23 "
		Manured	595 "	195 "	548 "	407 "
		Untreated	74 "	46 "	39 "	31 "

4. Numbers per gram of air-dry soil or per gram of root material studied.
5. Soils are listed in the same order as their position in containers; *i. e.*, for container a, untreated soil, top; steamed, middle; and manured, bottom layer.

adhering soil as possible, especially at the lower soil moisture contents. The effect of differences in moisture content of soil at time of sampling upon bacterial populations associated with root surfaces is indicated in table IV.

TABLE IV.—Effects of soil moisture at time of sampling upon bacterial populations associated with roots of wheat

Soil Moisture.	Total bacteria.[6] Soil.	Total bacteria.[6] Roots.	Spore-forming bacteria. Soil.	Spore-forming bacteria. Roots.
12.0%	73.5 × 10⁶	720 × 10⁶	53.2 × 10⁵	7. × 10⁶
14.2%	90.8 "	735 "	70.3 "	16.2 "
15.4%	83.3 "	675 "	60.8 "	21.0 "
19.4%	71.9 "	770 "	68.0 "	34.4 "
20.7%	57.9 "	565 "	43.7 "	40.3 "
24.5%	64.5 "	295 "	56.0 "	53.2 "

6. Numbers per gram of air-dry soil or per gram of root material studied.

DISCUSSION

Although the treatments employed had a marked effect upon soil bacteria (table I), total bacterial numbers associated with roots of wheat were in a large measure independent of soil populations (table II). Relatively low counts for bacteria on roots of wheat were obtained at first, regardless of soil treatment; later, root micropopulations in each soil rose to levels in excess of one billion. The increases in root micropopulations with increasing age of plants is in agreement with results previously reported by Starkey (*4*). Although at 64 days root bacterial populations following treatment separated into the same order as the soil bacterial populations (chicken-manured > green-manured > untreated), it is questionable whether differences in root micropopulations at this time can be ascribed directly to differences in soil micropopulations, particularly since at 30 to 45 days, when soil population differences were more pronounced, the numbers of bacteria associated with wheat roots showed closer agreement. Differences in plant responses because of treatments are doubtless of importance in the variable numbers of bacteria obtained on root surfaces with increasing age of wheat.

Determinations of root and soil bacterial populations from differently treated soil layers in single containers, where variations in plant responses were largely eliminated, again indicate independence between soil and root populations. With layered soils (table III) the manured soil invariably had the highest soil population, regardless of position in the container. The highest root micropopulations, however, did not generally parallel the highest soil micropopulations. In the majority of containers (table III), the highest numbers of total bacteria were found associated with root segments in the uppermost soil layer, regardless of the soil in this top layer. Therefore, the factor of soil treatment does not appear as important as the factor of position in container, upon total numbers of bacteria on roots. There is of course (table III) an unquestionable indication of some influence of soil micropopulations upon total bacterial populations associated with root surfaces. That such an influence was especially important for certain fractions of the total root micropopulation was evident in the enumeration of spores of aerobic bacteria.

Manured soils invariably had the greatest number of aerobic spores, regardless of position in container. Root segments from manured soil invariably possessed increased numbers of aerobic spores. Other work in progress on the rhizosphere of cotton has indicated that the spore-forming bacteria are not associated in appreciable numbers with the surface scrapings of roots of cotton, even when such roots are secured from soil showing greatly increased numbers of aerobic spores. In dealing with the fibrous root system of wheat, it is probable that soil particles, and therefore soil micropopulation effects, are not readily eliminated from root material collected.

The observations (table IV) obtained on root and soil samples collected from pots identical, except for differences in moisture content at the time of collection of samples, illustrate the probable occurrence of variable root sample contamination with soil particles. With increasing moisture contents at sampling, and therefore increased difficulty in obtaining root segments relatively free of soil, the ratio, $\frac{\text{root numbers}}{\text{soil numbers}}$, for spores of aerobic bacilli approached

unity for moist soils, but decreased to smaller fractions of unity with decreased moisture content at sampling. On the contrary, for total bacteria, the ratio, $\frac{\text{root numbers}}{\text{soil numbers}}$, showed the larger multiples of unity at decreased moisture content at sampling. It would therefore appear that a portion of the root surface microbial flora is intimately associated with root surfaces, and that this portion of the root microflora is not readily affected by soil amendments or by variations in the microflora of the adjacent soil.

SUMMARY

Soil amendments successful in the control of take-all of wheat and markedly affecting soil micropopulations have only slight effect upon the total numbers of bacteria associated with roots of wheat. Indirect influences may become apparent following treatments because of variations in the incidence of disease and in plant responses. Partial influences noted for total bacterial populations or for fractions thereof were believed to be due largely to the admixture of soil in the collection of root samples; it was observed that bacterial populations for roots from moist soils were more directly influenced by soil populations than those for relatively cleaner roots from dry soils. It is believed that there is an extreme localization of a true root surface bacterial flora which is not readily affected by soil amendments.

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Prairie Studies in West Central Kansas

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It is a popular belief that the margins of the dust bowl are gradually retreating toward its center as a consequence of the improvement of the vegetation contained therein. This belief is substantiated by meter quadrats charted in 1937 and again in 1938. Only the percent basal ground cover of buffalo grass (*Buchloe dactyloides*) and blue grama grass (*Bouteloua gracilis*) are shown in (Table 1, figures 1-3). These quadrats are located on a radius of the

TABLE 1.—Percent basal ground cover of Buffalo grass and Blue grama grass at different locations in Kansas

LOCATION OF QUADRATS.	Buffalo grass.		Blue grama grass.		Total.	
	1937.	1938.	1937.	1938.	1937.	1938.
Hays	4.20	6.70	19.00	33.90	23.20	40.60
Quinter (Av. of 5 quads.)	6.92	7.77	3.70	4.61	9.60	12.40
Oakley (Av. of 2 quads.)	7.84	19.48	6.35	10.10	14.20	29.60
Ness City (Av. of 5 quads.)	1.80	6.04	2.46	7.34	4.30	13.40
Amy (Av. of 2 quads.)	5.58	5.70	5.15	6.80	10.70	12.50
Dighton	.00	.00	.00	.00	.00	.00
Holcomb	.00	.00	.00	.00	.00	.00
Tribune	.00	.00	1.55	1.75	1.55	1.75

area occupied by the dust bowl, Hays being located near the periphery and Holcomb and Tribune toward the center. Data shown later (Table 2) indicate that there was a gradual decrease in vegetation from 1933 to 1936 or 1937, after which there was usually some recovery. This recovery extended for a distance of approximately 100 miles to the south and west of Hays. There was generally little or no improvement beyond Amy, Kansas. It should not be inferred from this table that no vegetation could be found west of Amy. The majority of pastures, however, were for the most part, similar to what is shown in table 1.

TABLE 2.—Percent basal ground cover of Blue grama grass, Buffalo grass, and total short grasses for 1932, 1937, and 1938 ungrazed

Blue grama grass.			Buffalo grass.			Total of short grasses.		
1932.	1937.	1938.	1932.	1937.	1938.	1932.	1937.	1938.
44.3	11.7	13.9	44.3	13.6	15.7	88.6	25.3	29.6

One writer has said, "The dust bowl lies on the knees of the great plains region. Roughly its center is the 103 counties clustered where Texas, New

Mexico, Colorado, Oklahoma, and Kansas meet." It would doubtless be difficult to establish the exact boundary of the dust bowl, for this would vary from year to year, and furthermore would depend upon one's point of view. The exact center can only be approximated, for variations in rainfall and other climatic conditions might cause a shifting of the area of greatest activity so characteristic of this "huge monster."

Surveys made into and through this area reveal the fact that from the periphery to the center the vegetation gradually becomes less and less, and wind and even water erosion, become constantly greater. The conditions in the center of this barren area have been little short of disastrous. Vast areas of pasture land are practically barren, with only an occasional yucca, lead plant, cactus, or pile of Russian thistles protruding through the tops of the long and tortuous drifts of fertile soil blown from the adjacent cultivated fields. In many places even the top one to four inches of soil in the prairies have been blown or washed away, leaving only small remnants of the native vegetation clinging tenaciously to a small cone of black soil.

Quantitative studies on the prairie near Hays, Kan., were begun in 1932. The drought began in 1933 and the basal ground cover was gradually reduced from 70 to 90 percent to 5 to 20 percent. The quantity of the most drought resistant native plants was not only decreased, but further than this, numerous species of native plants were completely annihilated.

The meter quadrat was used extensively in making these quantitative determinations. Some of these quadrats are located in typical shortgrasses (blue grama grass and buffalo grass), others in typical little bluestem (*Andropogon scoparius*) and still others on the ecotone between the shortgrasses and the little bluestem. Climatic conditions were unusually favorable for the development of vegetation during the years 1927 to 1932, inclusive. The basal ground cover found in the fall of 1932 would therefore seem to be a maximum which could be supported by the prevailing climatic conditions of this region. It was fortunate then that meter quadrats were charted at the close of this period, which was favorable for plant growth and continued annually thereafter. Beginning in 1933 the climatic conditions became less favorable for plant development. Rainfall, available soil moisture, and relative humidity of the air were decreased, while at the same time temperatures and wind velocities were increased. This period of drought beginning in 1933 has been the most intensive and extensive of any ever recorded in this region. It is no wonder then that the native vegetation suffered great losses.

The shortgrasses which occupied the higher tablelands where climatic conditions are presumably most xeric, had a basal ground cover between 70 and 90 percent in addition to the various forbs scattered throughout. This cover gradually decreased until 1936 or 1937, when the greatest decrease had occurred. Generally speaking the vegetation in this vicinity made considerable gains during the season of 1938. This condition is shown for the average of three quadrats in table 2, and further illustrated in chart form in figure 4. The basal ground cover for the quadrat shown in figure 4 was 89.45 percent in 1932. In 1937 it had been reduced to 20.7 percent, while in 1938 recovery had brought it up to 31 percent.

The little bluestem habitat which normally occupies the hillsides had a relatively high foliage cover but low basal ground cover in comparison to the

shortgrasses. The dominant grass in this habitat in 1932 was little bluestem, but big bluestem was frequently found scattered throughout in small amounts. In 1932 there was comparatively little of the side oats grama grass in the little bluestem habitat. It was interesting to note that as the drought progressed the little bluestem suffered severe losses. Big bluestem held its own or lost slightly while sideoats grama and even blue grama made very definite gains. This condition is shown in figure 5 and table 3. In table 3 the average percent of basal ground cover in nine quadrats is shown. The little bluestem decreased from 41 percent to 2.8 percent, while big bluestem at the same time decreased from 3.2 percent to 2.4 percent; also sideoats grama which was absent in 1932, had invaded the area and had a basal ground cover of 13 percent.

TABLE 3.—Average of nine quadrats showing percent basal ground cover of grasses ungrazed since 1932. Little bluestem habitat

Kind of Grass.	1932.	1936.	1938.
Little bluestem	41.6	5.7	2.8
Big bluestem	3.2	4.7	2.4
Sideoats grama	0.0	4.3	13.0
Total vegetation	44.8	14.7	18.2

On the ecotone between the shortgrasses and the little bluestem and its associates, there was considerable mixture between the two types of grasses in 1932. In some places where the topography changes abruptly from sloping to almost level land, the line of demarcation between the two types was rather sharp. In other places where the slope was gentle the little bluestem was scattered in occasional bunches through the shortgrasses over a rather wide belt. When the drought came in 1933, the more mesic little bluestem retreated far down the hillside and was replaced by the more xeric shortgrasses. In this case also the lowest percentage of basal ground cover was reached in 1936 or 1937 (table 4). The shortgrasses in an average of ten quadrats occupied approximately 20 percent. In 1934 it had been increased to 36 percent, due to a larger percentage of the quadrat being occupied by these grasses. The low was reached in 1936, with a percentage of 16.1, after which there was gradual improvement. Little bluestem gradually decreased from 37.8 percent to only a trace in 1938.

TABLE 4.—Average of ten quadrats to show basal ground cover of shortgrasses and little bluestem from 1932 to 1938

Shortgrasses.						Little bluestem.					
1932.	1934.	1935.	1936.	1937.	1938.	1932.	1934.	1935.	1936.	1937.	1938.
20.0	35.9	27.2	16.1	22.5	28.5	37.8	18.4	7.4	2.8	.82	.55

An attempt was made to discover if possible whether or not different intensities of grazing had any influence upon the loss of vegetation. Prairies that were ungrazed, ungrazed since 1932, lightly grazed, and heavily grazed were studied, beginning in 1935 (table 5 and figures 6 and 7). The prairies that were grazed lightly up until 1932 and ungrazed thereafter had a basal ground cover of 65.2 percent in 1935. This percentage was reduced to 25.3 in 1937 and then gained back to 29.6 percent in 1938. The area ungrazed had a heavy mat of shortgrasses and other plants over it in 1932. When the drought struck, these shortgrasses with heavy foliage were unable to survive and as a consequence greater losses were incurred than in prairies where light grazing was practiced. In the heavily grazed prairie the ground cover in 1935 was approximately the same as those lightly grazed and ungrazed, but the loss continued at a more rapid rate and in many places was completely annihilated by 1936. In 1938 considerable improvement occurred.

TABLE 5.—Percent basal ground cover of shortgrasses under different intensities of grazing

TREATMENT.	Total shortgrasses.		
	1935.	1936.	1938.
Ungrazed	20.5	8.5	17.3
Lightly grazed	24.4	6.9	34.0
Heavily grazed	24.5	1.9	9.7
Ungrazed since 1932	65.2	25.3 (1937)	29.6

CONCLUSION

It seems safe to assume that the dust bowl is gradually becoming smaller due to the gradual improvement of climatic conditions along the periphery as evidenced by the increased basal ground cover of the native grasses. Little or no improvement, however, was found nearer the center, as yet.

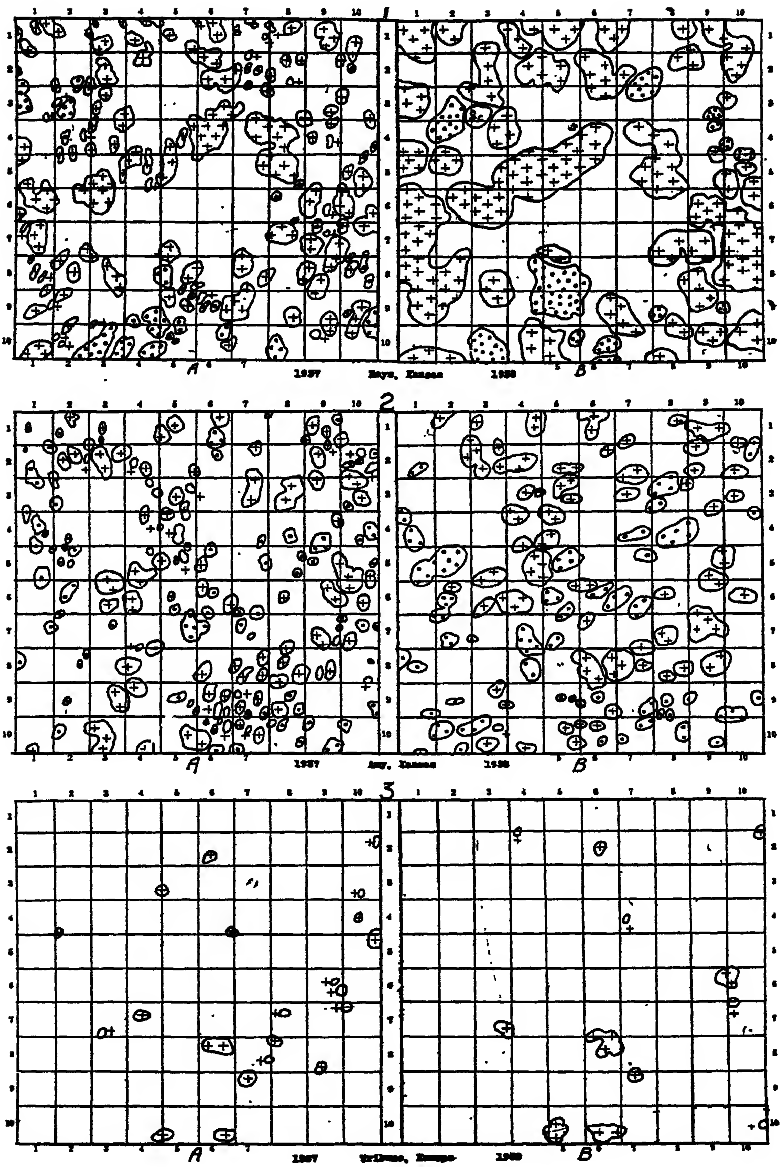
FIGURES 1, 2, 3

FIGURE 1. Meter quadrat showing percent basal ground cover at Hays, Kansas: (A) 1937, buffalo grass (stippled) 4.20, blue grama grass (crosses) 19; (B) 1938, buffalo grass 6.70, blue grama grass 33.90, sand drop seed, 0.45.

FIGURE 2. Meter quadrat showing percent basal ground cover at Amy, Kan.: (A) 1937, blue grama grass (crosses) 9.55, buffalo grass (stippled) 4.55; (B) 1938, buffalo grass 13, blue grama grass 7.9.

FIGURE 3. Meter quadrat showing percent basal ground cover at Tribune, Kan.: (A) 1937, blue grama 1.55; (B) 1938, blue grama grass 1.75.

FIGURES 1, 2, 3

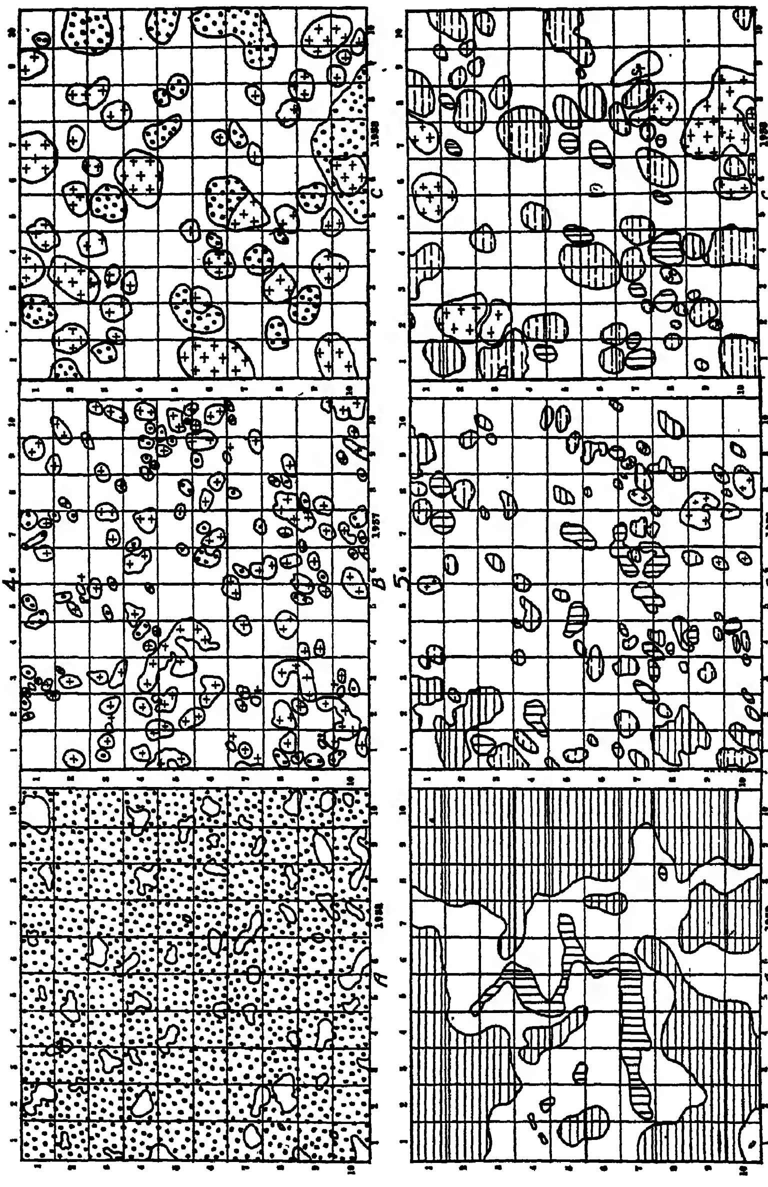


FIGURES 4 AND 5

FIGURE 4. Meter quadrat, showing percent basal ground cover of shortgrasses ungrazed since 1932: (A) 1932, shortgrasses (stippled) 89.45; (B) 1937, buffalo grass (stippled) 4.5, blue grama grass (crosses) 16.2; (C) 1938, buffalo grass (stippled) 15.4, blue grama grass (crosses) 15.75.

FIGURE 5. Meter quadrat showing percent basal ground cover in little bluestem habitat: (A) 1932, little bluestem (horizontal hatch) 55.86, big bluestem (perpendicular hatch) 6.9; (B) 1936, little bluestem 6.77, big bluestem 4.01, sideoats grama (broken horizontal hatch) 4.09, blue grama grass (crosses) 1.59, hairy sporobolus (Sp) 0.12; (C) 1938, little bluestem 2.2, big bluestem 3.5, sideoats grama grass 18.55, blue grama grass 8.45, hairy sporobolus 0.85.

FIGURES 4 AND 5

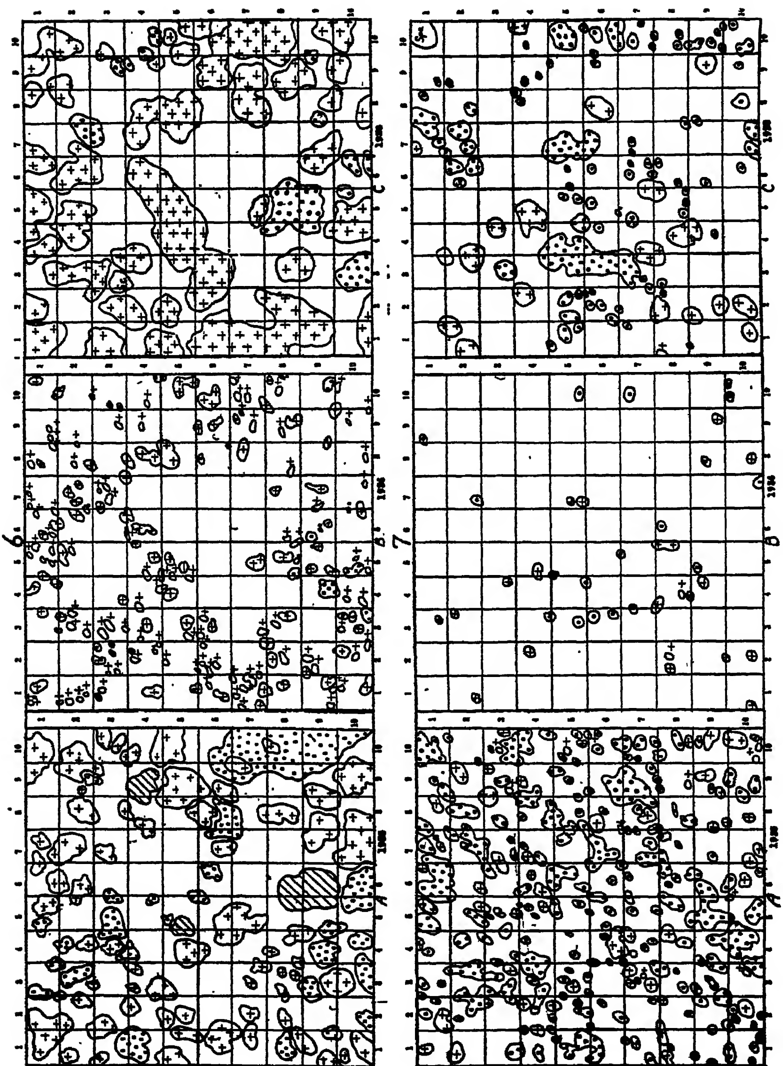


FIGURES 6 AND 7

FIGURE 6. Meter quadrat showing percent basal ground cover of shortgrass, lightly grazed: (A) 1935, buffalo grass (stippled) 14.61, blue grama grass (crosses) 16.41, wire grass (Aristida purpurea, diagonal hatch) 2.32; (B) 1936, buffalo grass 0.90, blue grama grass 5.01; (C) 1938, buffalo grass 6.70, blue grama grass 33.90, sand dropseed (Sporobolus cryptandrus Sc) 0.45.

FIGURE 7. Meter quadrat, showing percent basal ground cover of buffalo grass (stippled) and blue grama grass (crosses) under heavy grazing: (A) 1935, buffalo grass 20.78, blue grama grass 8.40; (B) 1936, buffalo grass 0.45, blue grama grass 0.60; (C) 1938, buffalo grass 9.49, blue grama 5.65.

FIGURES 6 AND 7



Seed Germination and Development of the Seedling in *Commelina virginica*[1]

JAMES C. BATES, Kansas State College, Manhattan, Kan.

The small black seeds of *Commelina virginica* are somewhat flattened on one side and convex on the other. The hilum extends nearly across the convex side of the seed. The tip of the radicle is covered by a disk-shaped operculum (figs. 1 and 2).

The seed consists of a relatively hard and impermeable seed coat which encloses a minute embryo and a comparatively large amount of endosperm consisting of starch and some protein. The embryo is straight, cylindrical, somewhat pointed at the radicle end and knob-shaped at the opposite end. The plumule is completely enclosed by the ensheathing base of the cotyledon (fig. 7).

Germination of the seeds is hastened by scarification; the radicles of some scarified seeds emerged within two days after planting. A photograph of several seedlings in different stages of germination is shown in figure 11.

During germination the operculum breaks at the margin and is forced to one side by the emerging radicle (figs. 3 and 4). The radicle, caulicle, and ensheathing base of the cotyledon with enclosed plumule are forced out of the seed by the elongation of the petiole of the cotyledon, while the scutellum remains within the seed and absorbs the endosperm. After the ensheathing base of the cotyledon has emerged from the seed, the petiole of the cotyledon is reflexed immediately above the ensheathing base, and the portion at the bend is modified into a soil-piercing point (figs. 4, 5 and 8). The soil-piercing point is then forced up through the soil by the elongation of the ensheathing base of the cotyledon and the caulicle. The petiole of the cotyledon also elongates at the same rate. When the soil-piercing point emerges from the soil, elongation ceases, and the plumule emerges from the ensheathing base of the cotyledon through a slit-like opening in its upper end (figs. 5 and 6).

If the seeds are planted at a depth greater than the combined length attained by the caulicle and ensheathing base of the cotyledon during their elongation, the plumule emerges from the sheath below the surface of the soil. The tip of the plumule is then forced up through the soil by the growth and elongation of the first leaf and internode of the plumule (fig. 10).

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Contribution No. 386, Department of Botany and Plant Pathology.

PLATE I

Commelina virginica

Figs. 1 and 2. Habit sketch of mature seeds.

Figs. 3, 4, 5, and 6. Habit sketch of seedlings in different stages of germination.

Fig. 7. Longitudinal section through mature seed.

Figs. 8, 9 and 10. Longitudinal sections through seedlings in different stages of germination.

a. Caulicle
b. Radicle
c. Petiole
d. Sheath
e. Plumule
f. Operculum
g. Endosperm
h. Soil line
i. Scutellum
j. Ensheathing base of petiole of cotyledon
k. Root initials
l. Adv. root
m. Testa
n. Embryo
o. Hilum

PLATE I

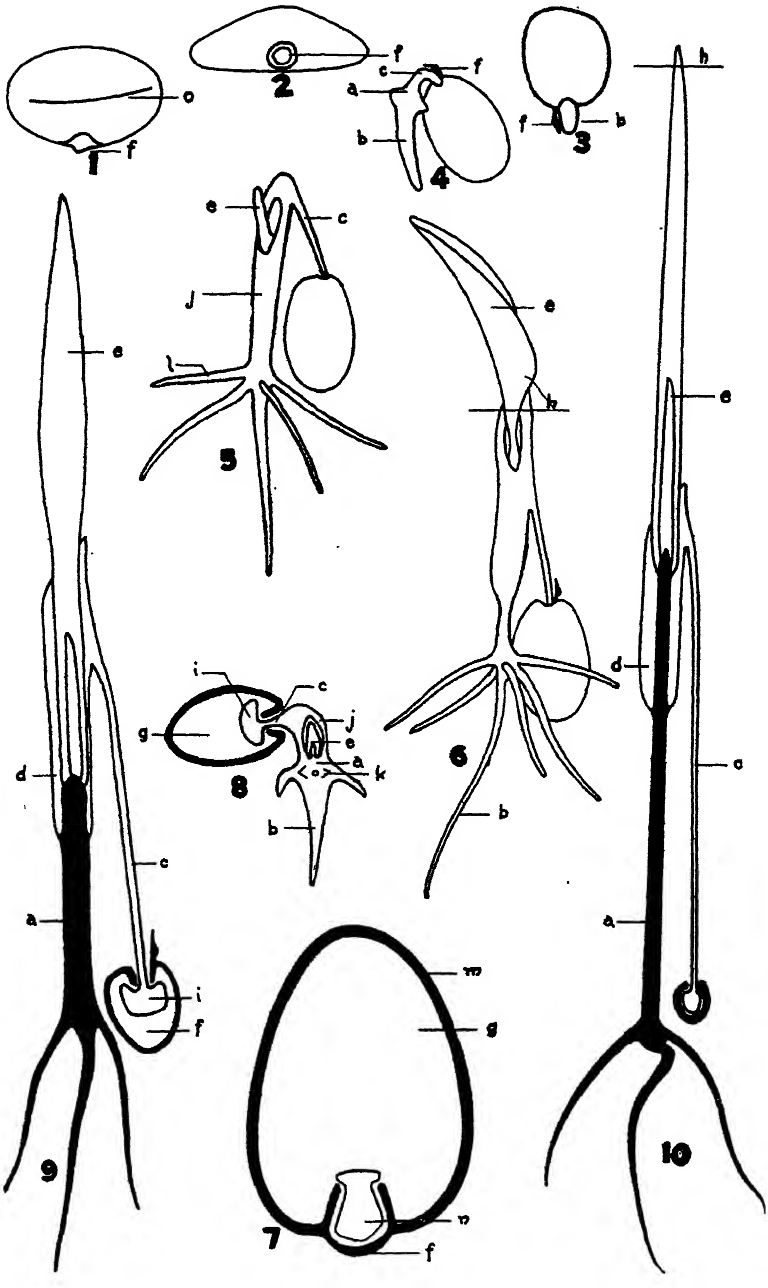


PLATE II

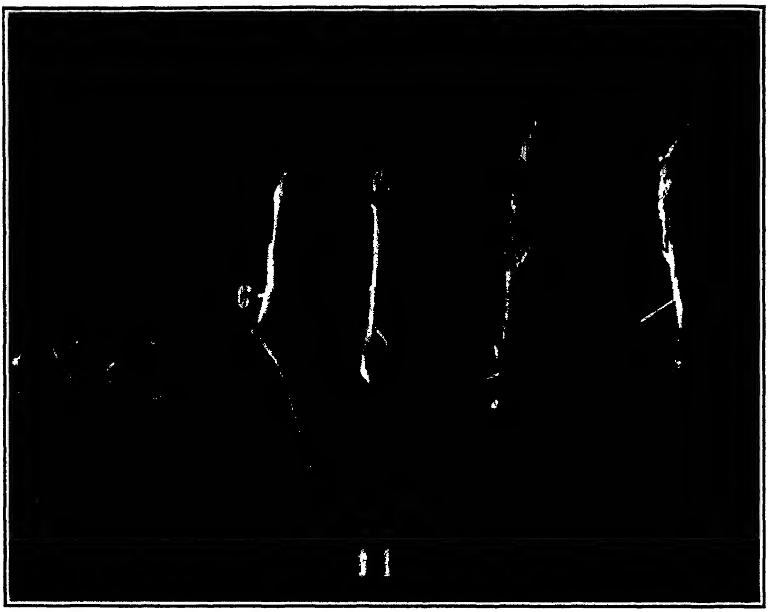


Fig. 11. Seedlings of *Commelina virginica* in different stages of development.

The Bearing of Zalenski's Law on Conifer Leaves[1]

LUCILE B. BURT, K. S. C., Manhattan, Kan.

Investigators (*3, 5*) have studied the size and frequency of stomata and cells in various distances from the base to the apex of the stem. Data have been obtained for broad-leaved trees and herbaceous plants. They have found an inverse relation between the number and size of the stomata and an increase in the number of stomata from the basal to apical leaves. They found also, an increase from the midrib outward to the margin of the leaf. The frequency increased with the distance from the main vascular supply. Zalenski (*4, 7*) stated that the higher the leaf is on the stem, the more vascular bundles there are and the greater is their extent per unit surface, the greater is the number of cells and the smaller their size, and the more stomata there are per unit of surface.

Work has been done on transpiring power of conifers as well as on broad-leaved trees and herbs. Results from these investigations (6, 8) show that when leaves are taken from several levels on a series of plants the intensity of transpiration per unit surface increases from the lower to the upper leaves notwithstanding the more xeromorphous structure of the upper leaves.

MATERIALS AND METHODS

For this study, cross and tangential sections were made from the mid-portion of the leaves which were selected from the basal, middle and apical parts of the tree. Pieces approximately 5 mm. in length, from the middle of the leaves, were put in acetic-formalin fixing and killing solution for 24 hours and then dehydrated and infiltrated with paraffin by the butyl alcohol method for infiltration. The sections were cut from the paraffin blocks, using the chopping microtome for *Pinus strobus* and *Juniperus virginiana* and the sliding microtome for the others. For the frequency determinations of the photosynthetic cells ten counts were made, the average taken and the frequency per mm.^{2} calculated. For the data regarding the size of the cells, twenty to fifty measurements were made and an average taken.

To obtain a stomatal count, small sections of the middle of the leaves were cleared by the method developed by Bates (*1*). Ten to twenty counts were made then and an average taken.

Camera lucida drawings were made from cross sections of leaves taken from the basal, middle, and apical parts of the tree. (Figs. 1-24.)

RESULTS

It was found that the average size of the leaf cells decreased from the base to the apex of the tree. (Table I.) This variation in size is shown in the drawings (figs. 1-24). The frequency of the photosynthetic cells increased from the base to the apex of the tree. (Table II.) Stomatal counts also showed an increase in their frequency from the base to the apex. (Table III.)

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1. Contribution No. 390 from the Department of Botany and Plant Pathology, Kansas State College, Manhattan, Kan.

DISCUSSION OF SEPARATE SPECIES

Abies concolor, Lind. and Gord. (Figs. 1-3.) The stomata are in alternate arrangement in rows on the upper and lower surfaces. They are in 6 to 7 rows on each side of the midrib on the upper side and in 5 to 6 rows on each side of the midrib on the lower side (2). The leaf vascular bundles of this species do not have a bundle sheath. Hypodermal cells are present on the margins and on the lower side of the leaf between bands of stomata. The guard cells and cells of the epidermis above them are lignified. The size of the cells varied from 50 x 80 microns at the apex of the tree to 52 x 96 microns at the base. Frequency of the photosynthetic cells varied from 684 at the apex to 556 at the base of the tree.

Juniperus virginiana, L. (Figs. 4-6.) This species has two kinds of leaves, needle-shaped and scale-like. The scale-like ones are found mostly on older parts while the younger parts have the needle shaped ones. The scale-like leaves were the ones used in this study. The drawings in figures 4-6 show a cross section through the middle of the leaves and a decrease in the size of the cells from the base to the apex of the tree is apparent. Their average size varied from 24 x 55 microns at the apex to 20 x 64 microns at the base. The frequency varied from 1150 at the apex to 868 at the base. The average number of stomata per $mm.^2$ varied from 436 at the apex to 350 at the base of the tree.

Picea pungens, Engelm. (Figs. 7-9.) The average size of the cells varied from 41 x 54 microns at the apex to 45 x 63 microns at the base of the tree. Their frequency varied from 1088 per $mm.^2$ at the apex to 960 per $mm.^2$ at the base of the tree.

Pinus banksiana, Lamb. (Fig. 10-12.) As in the other species of *Pinus* studied, the photosynthetic cells are very characteristic in shape. The cell wall projects inward as shown in figures 10-21, thereby allowing more surface for the chlorophlasts. A well-defined endodermis is present in each of the species. *Pinus banksiana* has two vascular strands. The cells vary in size from 39 x 62 microns at the apex to 47 x 75 microns at the base. Their frequency varied from 1824 per $mm.^2$ at the apex to 1271 per $mm.^2$ at the base. The average number of stomata at the apex was 47 and at the base 40.

Pinus laricio, Poir. (Figs. 13-15.) This species has two vascular strands and several rows of hypodermal cells. The size of the photosynthetic cells vary from 46 x 52 microns at the apex of the tree to 47 x 70 microns at the base. The frequency varied from 2238 per $mm.^2$ at the apex to 1300 per $mm.^2$ at the base of the tree. The stomatal frequency varied from 61 per $mm.^2$ at the apex to 58 per $mm.^2$ at the base of the tree.

Pinus strobus, L. (Figs. 16-18). The stomata in this species, as in the other species of Pinus, are arranged in rows. They extend longitudinally along the two flat sides of each needle and are sunken below the epidermis. An accessory epidermal cell of similar shape is superimposed upon each guard cell. The guard cells differ in appearance depending upon the plane through which they were sectioned. This is true of the other species, also. *Pinus strobus* has one vascular strand. The average size of photosynthetic cells varied from 41 x 46 microns at the apex to 48 x 68 microns at the base.

The frequency varied from 1174 per mm.^{2} at the apex of the tree to 1067 per mm.^{2} at the base. The average number of stomata varied from 61 per mm.^{2} at the apex to 58 per mm.^{2} at the base of the tree.

Pinus sylvestris, L. (Figs. 19-21.) The average size of the photosynthetic cells at the apex of the tree is 47 x 54 microns and at the base is 49 x 65 microns. Their frequency at the apex is 2560 per mm.^{2} and at the base 1824 per mm.^{2} The average number of stomata is 94 per mm.^{2} at the apex and 46 per mm.^{2} at the base of the tree.

Thuja orientalis, L. (Figs. 22-24.) The average size of cells at the apex of the tree is 15 x 40 microns and at the base 18 x 44 microns. The average number of stomata per mm.^{2} at the apex is 119, and at the base is 86.

SUMMARY

1. The results of this investigation show that the cells decrease in size and increase in frequency from the basal to the apical parts of these conifers.
2. The stomatal frequency increases from the basal to the apical parts of these conifers.
3. This bears out the observations made on plants in general that the frequency of cells increase with the distance from the main vascular supply. The stomatal frequency also increases as the vascular supply of the midrib diminishes.

TABLE I. The size of photosynthetic cells from the basal, middle and apical parts of the tree, in microns.

Conifer	*Base*	*Middle*	*Apex*
Abies concolor	52.8 × 96.4	50.4 × 88.2	50.6 × 80.1
Juniperus virginiana	29.1 × 64.7	34.3 × 63.6	24.4 × 55.7
Picea pungens	45.9 × 63.1	42.9 × 58.7	41.4 × 54.1
Pinus banksiana	47.5 × 75.7	41.8 × 74.8	39.4 × 62.5
Pinus laricio	47.7 × 70.8	48.4 × 58.5	46.2 × 52.1
Pinus strobus	48.2 × 68.2	43.8 × 49.7	41.1 × 46.2
Pinus sylvestris	49:1 × 65.6	50.2 × 62.5	47.7 × 54.8
Thuja orientalis	18.3 × 44.2	16.3 × 43.1	15.8 × 40.5

TABLE II. The frequency of photosynthetic cells from basal, middle and apical parts of the tree, expressed in number per mm.^{2}

Conifer	*Base*	*Middle*	*Apex*
Abies concolor	556	637	684
Juniperus virginiana[2]	868	1091	1150
Picea pungens	960	990	1088
Pinus banksiana	1271	1397	1824
Pinus laricio	1067	1086	1174
Pinus strobus	1300	1663	2238
Pinus sylvestris	1824	1956	2560

TABLE III. The stomatal frequency of leaves from the basal, middle and apical parts of the tree, expressed in number per mm.^{2}

Conifer	*Base*	*Middle*	*Apex*
Juniperus virginiana	350	378	436
Pinus banksiana	40	44	47
Pinus laricio	58	56	61
Pinus strobus	63	64	74
Pinus sylvestris	46	73	94
Thuja orientalis	86	88	119

2. Counts were made from tangential sections, except those for *Juniperus virginiana*, which were made from a cross-sectional view.

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EXPLANATION OF PLATES

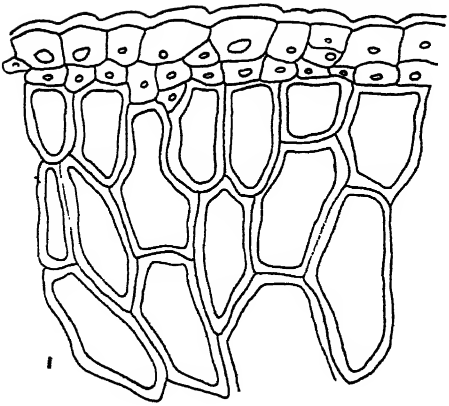
Sections of Leaves of Various Conifers Taken from the Designated Parts of the Crown

The figures were drawn at approximately 840 × magnification. A camera lucida was used with a Spencer microscope. Figures were reduced about one-third.

PLATE I

Figs. 1-3. *Abies concolor,* Lind. and Gord. 1, apex. 2, middle. 3, base.
Figs. 4-6. *Juniperus virginiana,* L. 4, apex. 5, middle. 6, base.

PLATE I



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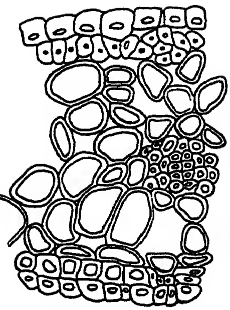

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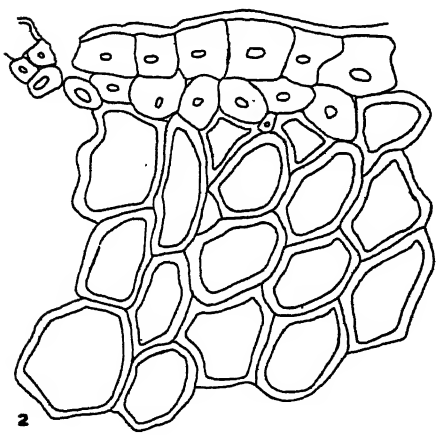

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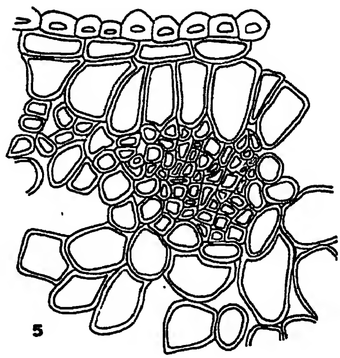

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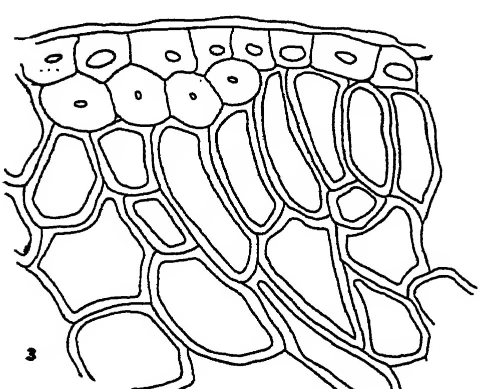

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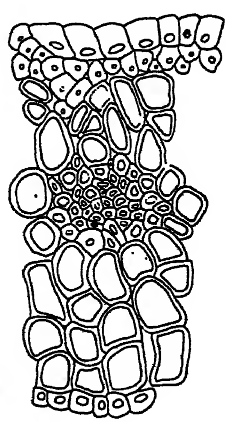

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PLATE II

FIGS. 7-9. *Picea pungens,* Engelm. 7, apex. 8, middle. 9, base.
FIGS 10-12. *Pinus banksiana,* Lamb. 10, apex. 11, middle. 12, base.
FIGS. 13-15. *Pinus laricio,*. Poir. 13, apex. 14, middle. 15, base.

PLATE II

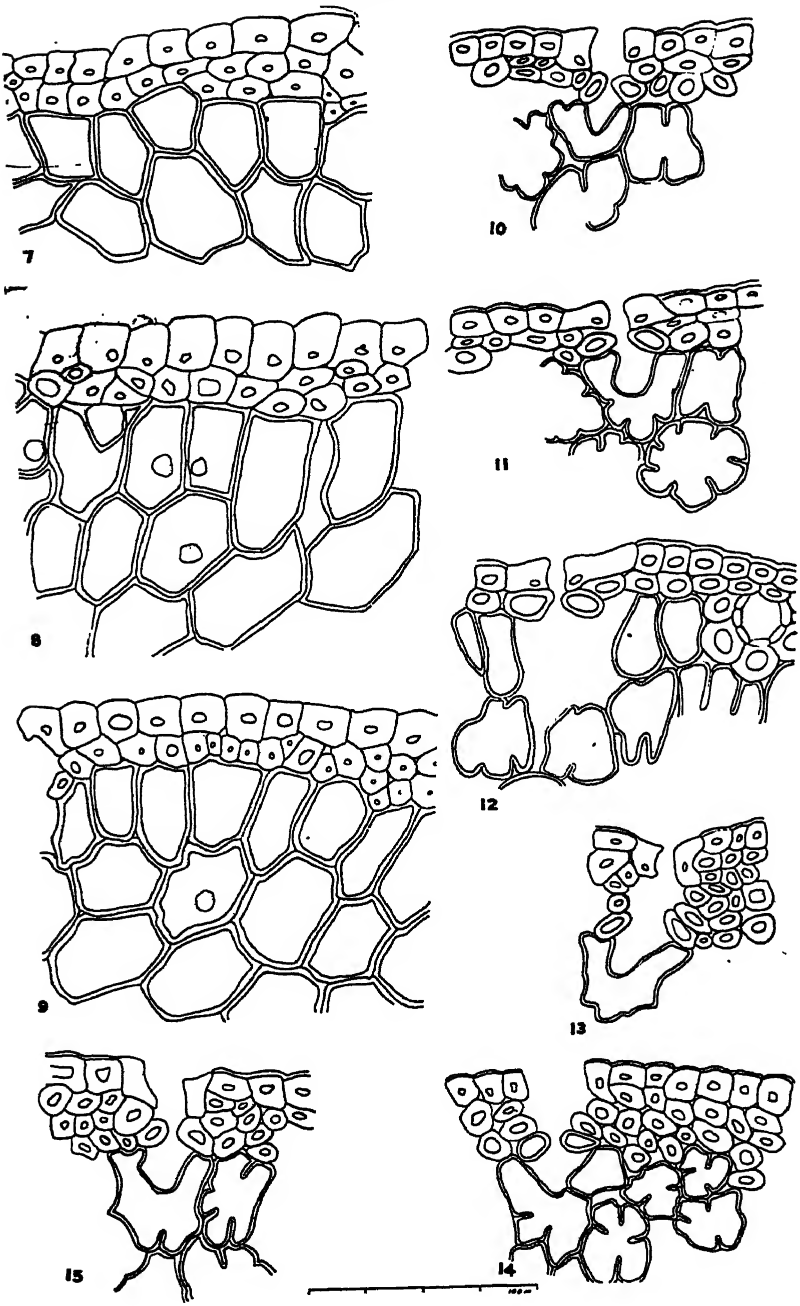
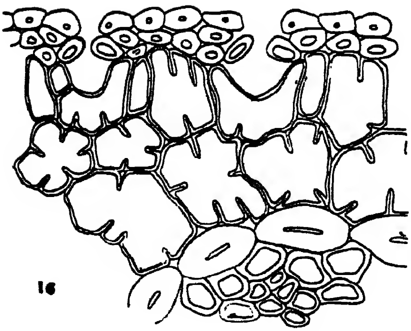


PLATE III

FIGS. 16-18. *Pinus strobus,* L. 16, apex. 17, middle. 18, base.
FIGS. 19-21. *Pinus sylvestris,* L. 19, apex. 20, middle. 21, base.
FIGS. 22-24. *Thuja orientalis,* L. 22, apex. 23, middle. 24, base.

PLATE III



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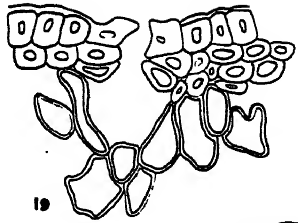

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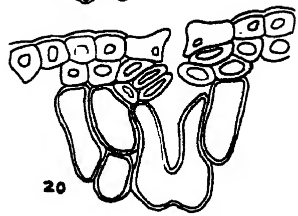

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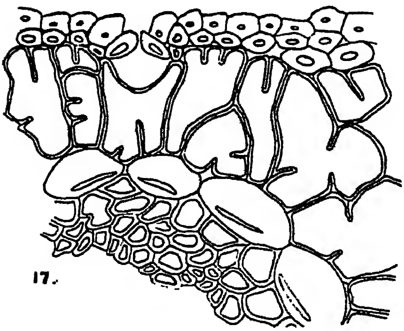

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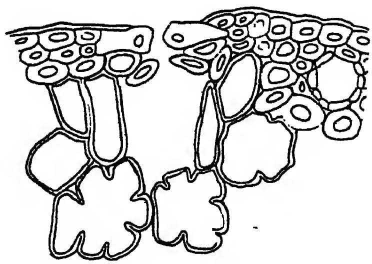

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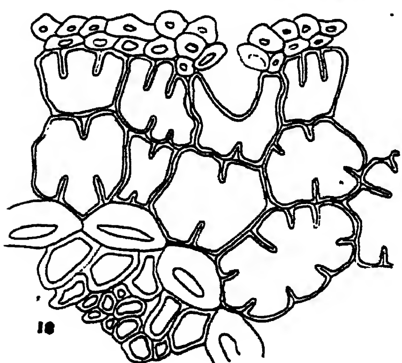

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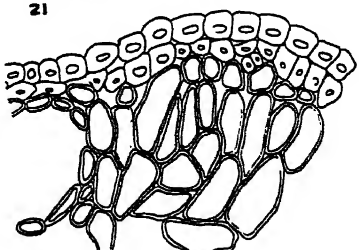

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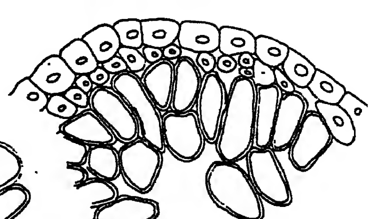

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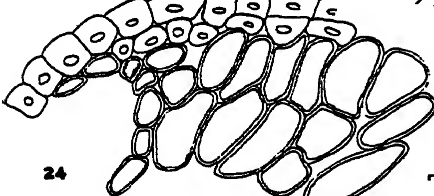

24

Allium perdulce: A New Allium from Kansas

S. V. FRASER, Aurora, Kan.

In the spring of 1929, while making a survey of the flora of Cloud county, Kansas, I came upon a colony of small wild onions growing on the slope of a dry, rocky sandstone hill about eight miles north of Aurora. The patch was not very large, covering, perhaps, a square rod or two, but its brilliant display immediately arrested my attention, and particularly at that early date—it was about the middle of April—as our commoner onion *Allium nuttallii* S. Wats. does not come into full bloom until about the middle of May. Several specimens were picked and a comparative study was made with *Allium nuttallii*, the only small onion recorded in the manuals for Kansas. The plant just did not seem to key in with the description of the latter and I listed it tentatively, though in error, as *Allium textile* Nels. & MacBr., and so deposited it as No. 72 in the herbarium of the Kansas State College, Manhattan.

In the spring of 1937, when the little gay-colored *Anemone caroliniana* came out in such profusion, it seemed that this new onion vied for similar honors. It was seen growing abundantly in the Dakota sandstone formation throughout the county. I came upon a large colony four and one-half miles south of Aurora, on the Tootle section, covering two or three acres. A light breeeze carried the sweeet lily-like fragrance of the blossoms toward me while yet several hundred yards away. The plant is very irregular in its appearance in this part of the state from year to year, a phenomenon that may be due to the fact that we are on the fringe of its geographic range. Not one plant showed up in that colony the following year nor in any of the other localities where it had been so abundant before. One large field, however, covering some five or six acres, was discovered that year in quite an unusual location. The site is about one mile southeast of the dam of the state lake northwest of Jamestown. The onions grew in a heavy gumbo soil that is frequently flooded by the salty water from the marsh nearby. The plants were not more than four or five inches tall, but well-developed and very abundant. Several other colonies of more luxuriant growth were observed in a few counties of western Kansas, where the plant appears more regularly every year.

Much time has been spent in an effort to determine if this onion had not already been described. The manuals covering the central and southern states carry no description of it. Specimens were sent to the neighboring state universities; to Dr. C. O. Erlanson of the Bureau of Plant Industry, Washington, D. C.; to Dr. Louis C. Wheeler, Harvard, and to several others. The material seemed to be unfamiliar to them. Several suggested that the plant might be treated tentatively, at least, as a good variety of *Allium nuttallii.* A study and comparison was made of related species as *Allium helleri* Small; *A. arenicola* Small; *A. microscordion* Small; *A. hyacinthoides* B. F. Bush. The last mentioned deserved some consideration. The others were simply "out." According to the description of *Allium hyacinthoides* as it appears in the annual report of the Missouri Botanical Garden, 1906, there seems to be much in common with *Allium perdulce.* I have been unable to procure any material for

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the comparison, but from the description I find that the following points are at variance with *Allium perdulce*: in the former the leaves are much shorter than the scape; the pedicels filiform; flowers pink; perianth segments thin and having a reddish midvein; filaments not much dilated; the capsules smaller than in *Allium mutabile,* whereas in *Allium perdulce* they are larger.

A critical study of *Allium nuttallii* S. Wats. was made and so many basic differences observed between it and the Allium in question that it seemed reasonable to dismiss the notion of their relationship. But since the collectors have confused these two plants, the following comparative study is offered to show the salient points of divergence:

	Allium nuttallii S. Wats.	*Allium perdulce* sp. nov.
Bulb:	Fibrous coat ribbed longitudinally, finely meshed, tightly woven, rigid and mostly opaque.	Fibrous coat not ribbed, the meshes large and open; coarse. A finely nerved hyaline membrane between layers.
Leaves:	Ribbed dorsally, channelled to the tip, 3-8 mm. broad, relatively thin, pale green.	Not ribbed dorsally, only partly channelled, the upper part flattened or terete, dull dark green, 1.5-3.5 mm. broad, slender, roundish.
Scape:	10-30 cm. tall, irregularly ribbed or sulcate.	10-25 cm. tall, smooth and terete.
Bract:	One nerved.	3-7 nerved, usually five.
Flowers:	Campanulate, odorless, white, pink or rose, 10-25 to the umbel.	Urceolate, very fragrant, all rose colored, 5-25 to the umbel.
Perianth segments:	Erect upon withering, 5-8 mm. long.	Enveloping the capsule upon withering, 7-10 mm. long.
Seeds:	Bright black: Superficial cells tuberculate.	Dull black: Superficial cells granular, not tuberculate.
Blooming date:	About May 15 here.	About April 15 here.

Allium perdulce S. V. Fraser, sp. nov. Bulbis plerumque aggregatis 1 cm. latis et circiter 2 cm. altis, ovatis, tegimine fimbrio-reticulato coöpertis; stratis tegiminis crassis, sine nervis longitudinalibus; foliis cauli aequalibus vel paulo brevioribus, angustis, 1.5-3.5 mm. latis, levibus, non sulcatis striis dorsalibus, leviter canalulatis a medio ad basin versus, parte superiora paulo compressis aut fere teretibus atrovirids (dull dark green); caule 10-25 cm., alto, rigido, erecto, terete, levigato, non sulcato; bracteis 2 vel 3, ovato-lanceolatis acuminatis, 12-18 mm. longis, 3-7 nervatis sed communiter 5; umbella simplici, erecto, 5-25 floribus ornata, non bulbifera; pedicellis tenuibus sed non filiformibus, 7-15 mm. longis; floribus urceolatis, fragrantissimis, roseis; segmentis perianthi 7-10 mm. longis, firmis, ovatis vel ellipsis, obtusis arescentibus capsulam amplectentibus; filamentis multo ad basin versus latioribus; capsula 4.5-5 mm. lata, sine, cristis; semen nigrum (dull black).

Bulbs mostly in clusters, 1 cm. wide and nearly 2 cm. long, ovate, with fibrous reticulate coat; the layers of the coat coarse, without longitudinal ribs; the leaves equaling or slightly shorter than the scapes, narrow, 1.5-3.5 mm. wide, smooth, not sulcate, without dorsal grooves, slightly channelled from about the middle to the base, the upper part flattened or nearly terete, dull dark green; scape 10-25 cm. tall, rigid, erect, terete, smooth, not sulcate;

bracts two or three, ovate-lanceolate, acuminate, 12-18 mm. long, 3-7 nerved, but usually 5; the umbel simple, erect, 5-25 flowered, flowers not replaced by bulbets; the pedicels slender, but not filiform, 7-15 mm. long; flowers urceolate, very fragrant, rosecolored; the perianth segments 7-10 mm. long, firm ovate or elliptic, obtuse, enclosing the capsule when withering; filaments much broader at the base; the capsule 4.5-5 mm. broad, not crested; the seeds dull black.

The type specimen has been placed in the herbarium of the Kansas State College at Manhattan; cotypes were sent to the Gray Herbarium, Harvard; National Herbarium and the Bureau of Plant Industry, Washington, D. C.

The range extends from north central Texas through central Oklahoma, central Kansas, central and eastern Nebraska and probably into South Dakota.

KANSAS: Sedgwick Co., A. S. Miller, May, 1892. Rooks Co., Zurich, Elam Bartholemew, April 25, 1889; Mrs. C. W. Swalp, April 30, 1929. Saline Co., No. 154, John Hancin. No locality, W. A. Carleton, April 18, 1888. Cloud Co., S. V. Fraser, No. 71, April 20, 1929. The Ft. Hays Kansas State College at Hays, Kan., has specimens from Ellis, Trego, and Rooks counties. The plant was observed growing in Graham, Osborne, Jewell, Republic, and Ottawa counties.

NEBRASKA: Holt Co., east of Atkinson, W. L. Tolstead, May 25, 1937, excellent and typical specimens. Dodge Co., Fremont, Carl C. Engberg, June 1894. Lancaster Co., Lincoln, E. B. Robinson, May, 1895. Brown Co., Long Pine, C. M. Stevans, May 9, 1887. Furnas Co., Oxford, A. Isabel Mulford, May 13, 1892. Sherman Co., Loup City, Rev. J. M. Bates, May 14, 1907. Antelope Co., No. 5282, H. J. Webber, 1887; Neligh, no date, H. L. McGinitie. Phelps Co., Holdridge High School, May 30, 1890. The Nebraska data is derived from the herbarium of the University of Nebraska.

TEXAS: Palo Pinto Co. V. L. Cory, March 28, 1939.

OAKLAHOMA: Noble Co., near Perry, Christia Allender, April 19, 1929, No. 3467: Kiowa Co., gumbo soil, Richland Store, No. 224, Opal Baldock, April 27, 1938; Gargeld Co., grassy prairie near Enid, No. 206, G. W. Stevens, April 26, 1913; near Lahoma, No. 206, G. W. Stevens, April 26, 1913.

The specimen from Texas is in my possession and was picked for me by Dr. Victor L. Cory, of the Texas Agricultural Experiment Station, Sonora, where material of the species is also on file. The data for Oklahoma was derived from the material in the A. & M. College, Stillwater which I reviewed recently.

In the description of *Allium perdulce* stress has been placed on the morphological characters of the reticulate bulbcoat. Its coat is coarse and stiff, with open network of relatively large meshes, and having between its layers a fine nerved hyaline membrane. What seems strange is that there are no perpendicular nerves or ribs on the coat, as is so common with coat of the other species. In *A. textile* Nels. & Mac Br. the coat is open, but very finely reticulate, with nerves that are slightly zigzag and channeled. In *Allium nuttallii* S. Wats. the coat is tightly woven and more like a shell, the netting open where the shell has burst from growth, or toward the top, and the ribs are fine and straight.

I think that anyone undertaking to monograph the genus Allium might do well by relying somewhat on the peculiarities of the reticulate bulb-

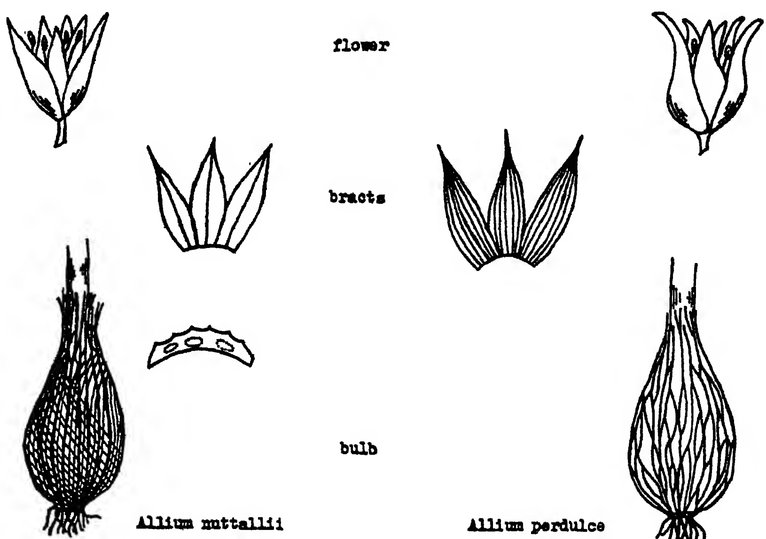
coats for two reasons. These fibrous reticulate coats provide quite distinctive characteristics that prove very helpful in determining species. I have before me several such coats of different species, well pressed out, and their differences are easily discernible. In the process of preparing Allium specimens some good determining characters vanish, whereas those of the bulbcoat are usually quite permanent. The same may be said to a degree of the bracts and their venation.

There are, therefore, three distinct species of small Alliums with an extensive range in the central plains states that may be readily classified according to the following key:

KEY

Bulbcoat fibrous reticulated.
- Scape 10-25 cm. tall.
  - a. Capsules not crested.
    - 1. Perianth segments erect when withered, bract one-nerved, flowers odorless, bulbcoat longitudinally ribbed. *A. nuttallii.*
    - 1. Perianth segments enclosing capsule when withering, bracts five nerved, flowers very fragrant, bulbccat not ribbed longitudinally. *A. perdulce.*
  - a. Capsules crested. *A. textile.*

I wish to express my deep appreciation to Dr. F. C. Gates, to Dr. O. C. Erlanson, and Dr. Louis C. Wheeler and others for the assistance given in the preparation of this paper.



Drawings of the two species arranged so as to compare details of structures.

Trends of Tree Migration in Kansas[1]

F. C. GATES, Kansas State College, Manhattan, Kan.

Rather thorough collections of woody plants were made in all the counties of Kansas during the 1890's and deposited in the Kansas State Herbarium at Manhattan. Recent collections have been almost entirely made since 1925. Mapping the county location of these collections indicates some of the trends of migration.

In last year's TRANSACTIONS will be found an up-to-date list of woody plants of Kansas with maps of their known (herbarium specimens) distribution.[2]

More than half (45) of the trees in this list have not in the past fifteen years been collected beyond the bounds established by the last century collections. Among these may be mentioned: *Asimina triloba,* the papaw (map 1);[3] *Benzoin aestivale,* spicebush (map 2); *Sassafras albidum,* sassafras (map 3); *Tilia americana,* basswood; *Celtis occidentalis,* hackberry; *Ulmus americana,* American elm; *Ulmus fulva,* slippery elm; *Populus deltoides* or *Populus virginiana,* cottonwood; *Salix interior,* sandbar willow; *Vaccinium stramineum,* blueberry (map 3); *Fraxinus pennsylvanica lanceolata,* green ash; *Prunus besseyi,* Bessey sandcherry (map 4); *Prunus virginiana,* chokecherry; *Acer nigrum,* black maple; *Acer saccharum,* sugar maple; *Carya laciniosa,* bigleaf shagbark hickory; *Juglans nigra,* black walnut (map 5); *Betula nigra,* river birch; *Quercus imbricaria,* shingle oak; *Quercus marilandica,* blackjack oak; *Quercus prinoides,* shrub oak; *Quercus stellata,* post oak (map 6); *Cornus florida,* flowering dogwood (map 3); and *Viburnum rufidulum,* rusty black haw.

Migrations among the tree species could be expected in varying degrees from any of the cardinal points of the compass. Migrations from the north are not found among the trees of Kansas, but are well known among some of the herbaceous plants. Migrations up from the south show best in the case of *Prosopis chilensis glandulosa* mesquite (map 8), which was not known in Kan-

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Contribution No. 387, Department of Botany and Plant Pathology.
2. The following emendations and corrections may now be made:
   Trans. Kan. Acad. Sci. 41:
   Page 100, line 14. *Smilax pseudo-china.* In absence of knowledge of a type it may be wiser to consider these specimens as *Smilax hispida* with unusually long peduncles and delete map 4.
   Page 100, line 15. *Smilax rotundifolia.* The western specimens of *S. bonanox* without fiddle-shape leaves. Delete map 5, and add hollow circle (ring) in Douglas Co. to map 2.
   Page 101, line 5. Make it read Maclura.
   Page 102, after line 4, add *Salix nigra lindheimeri* Schneider, Neosho Co., July, 1939, (C. R. Ball).
   Page 103, line 11 and also map 76. Make it read *Rubus flagellaris occidualis.*
   Page 103, line 18. Make it read Amelanchier.
   Page 103, line 30. Make it read Crataegus.
   Page 108, line 9. Make it read dioica.
   Page 108, line 20 and also map 203. In place of *V. lentago* make it read *Viburnum prunifolium bushii.*

3. On each of the maps a small square indicates an herbarium specimen dating about 1899 or earlier, a large square indicates an herbarium specimen of recent collection (since 1925 with few exceptions) in counties from which no earlier specimen had been obtained. A "C" used in a few maps indicates a cultivated specimen.

sas in the last century, but is now known in Kiowa county. *Bumelia lanuginosa,* woolly buckthorn (map 7), previously known from southeastern Kansas, has been migrating northward to southwest of Kansas City, just about doubling its previous extension into Kansas. *Ilex decidua,* holly (map 9), a shrub rather than a tree, has spread both north and west.

Taking up eastward and westward migrations, we find several examples in each direction. Among those migrating eastward, the most conspicuous is without doubt *Tamarix gallica,* tamarisk (map 10), which apparently came into Kansas from Colorado on floods of the Arkansas river in the 1920's and in the past few years has spread on sandbars nearly half way across the state. Apparently from this source disseminules have gotten into the big salt marshes in the Great Bend territory. There tamarix thickets are now extensive. Floods of the Republican river brought in seeds of *Cercocarpus montanus,* mountain mahogany (map 11), which have been picked up among other plants in recent years, but how well the plants are becoming established is as yet unknown.

The western chokecherry, *Prunus virginiana melanocarpa* (map 12), spread primarily by birds and rodents, is making headway eastward across northern Kansas. Other species include a hackberry, *Celtis rugulosa,* the plains cottonwood, *Populus sargentii,* a willow, *Salix exigua luteosericea,* the plain ash, *Fraxinus pennsylvanica campestris,* and a plum, *Prunus rugosa.*

Spread to the west is, however, most common. The work of Miss Pearl Maus, in Wabaunsee county, indicated that most of the spread of trees as individuals was merely a reclaiming of land that trees would otherwise have been expected to occupy had it not been for the prairie fires. Consequently this was not real migration. This is true at least as far west as Riley county. When, however, as in the examples below, the plants are now found in counties beyond these limits, it would appear to be safe to accept most of them as real examples of present-day migration. Among those in which the migration has been but the jump of a county or two are *Cercis canadensis,* redbud (map 13); *Gymnocladus dioica,* Kentucky coffeetree (map 14); *Platanus occidentalis,* sycamore (map 15); *Sapindus drummondii,* soapberry (map 16); *Carya cordiformis,* bitternut or yellowbud hickory (map 17); *Quercus alba,* white oak, *Quercus muhlenbergii,* Muhlenberg oak (map 18).

Among those which have been collected recently two or more counties to the west are *Morus rubra,* red mulberry (map 19); *Ptelea trifoliata,* hoptree (map 20); *Ailanthus altissima,* tree of heaven (map 21); *Salix amygdaloides,* peachleaf willow (map 22); *Prunus angustifolia,* chickasaw plum (map 23); *Prunus hortulana,* plum (map 24); *Gleditsia triacanthos,* honey locust (map 25); *Aesculus glabra sargentii,* western buckeye (map 26); *Acer negundo,* boxelder (map 27); *Acer saccharinum,* soft or silver maple (map 28); *Quercus borealis maxima,* red oak (map 29); and *Quercus macrocarpa,* bur oak (map 30). In this list all are native trees except Ailanthus, which, however, is now well established in many places.

In looking into possible factors in part explaining these migrations, one can mention first the checking of prairie fires, giving disseminules a chance to develop. Perhaps second, the general tendency of our present day towards amelioration from the last ice age, in which the somewhat warmer

and somewhat drier conditions favor a northeastward migration. Since the country southwest from Kansas is not a country of trees, the tree population of Kansas does not show this effect as it is shown among herbaceous plants. The spread of disseminules by flood certainly has been responsible for some of these migrations. However, the species present to the west from which all Kansas streams ultimately come, are not species which establish themselves under Kansas conditions. For trees migrating to the west, we have the apparent anomaly of species migrating along streams, but against the prevailing direction of stream flow. This is very obvious among such species as *Cercis canadensis, Acer negundo* and *Salix amygdaloides,* to mention but a few.

The prevailing wind direction in the state is a westwardly one, southwest during a good many months. This could easily explain wind-carried seeds, but as previously stated, these trees are for the most part migrating westward. East winds strong enough are not common and are quite likely to be rain winds which are less useful in spreading seeds. Man, of course, has something to do with the spread of some of these trees, as he plants trees in towns. From such trees seeds eventually spread in the vicinity. The present distribution of *Acer saccharinum* and of *Gleditsia triacanthos* in part has such an explanation.

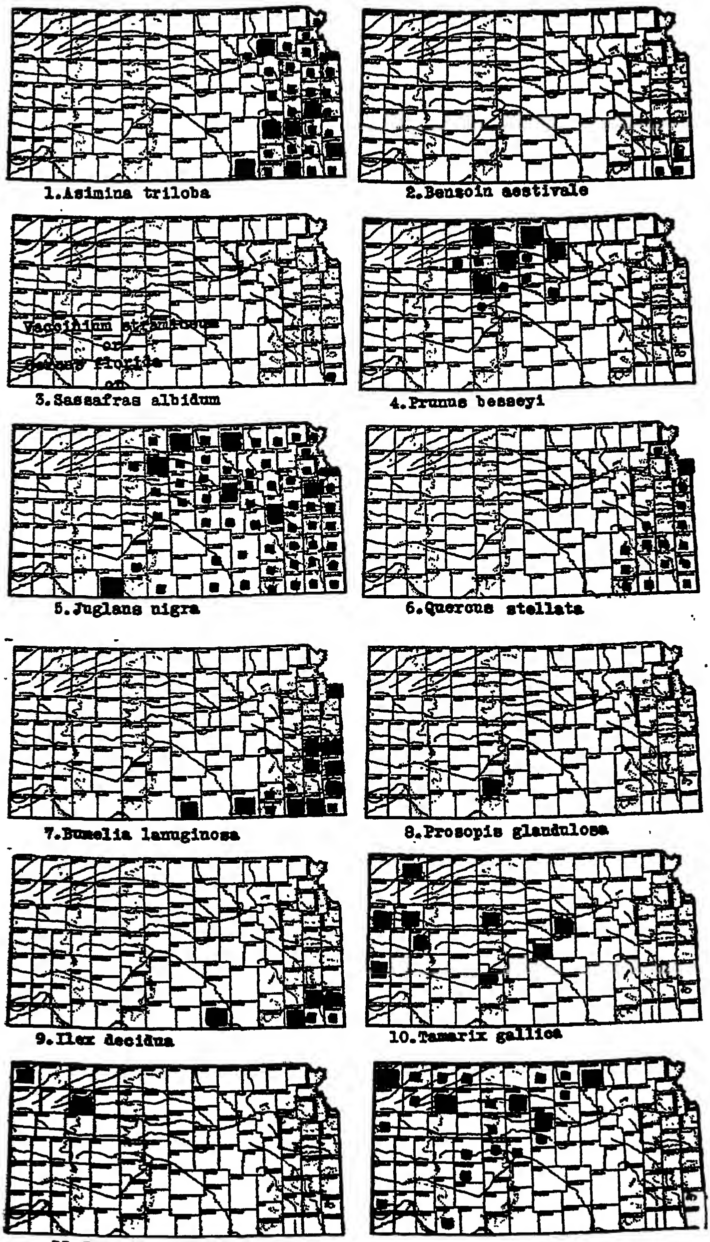
SUMMARY

More than half of the tree species in Kansas show no additional counties or extension of range during the past thirty or thirty-five years.

Three examples of northward migration and no cases of real southward migration are known.

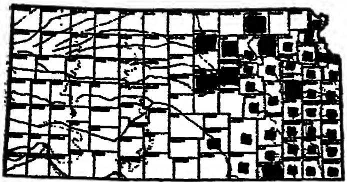
Migration to the eastward is only occasional (about nine species) and is at its best with the introduced *Tamarix gallica.* Migration towards the west, however, against the prevailing winds and against the direction of stream flow, is very much the commonest type (at least thirty-one species). Part of this is a reëstablishment on land which would have been forested if there had been no prairie fires, but with the greater protection given streams at the present time, noteworthy migration beyond that limit is obvious even within the first third of this century.

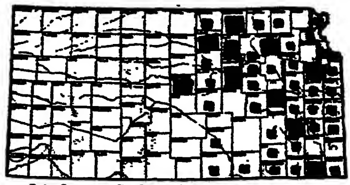
PLATE I

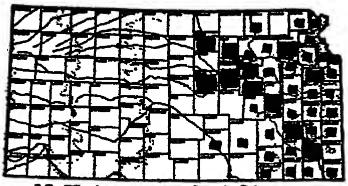


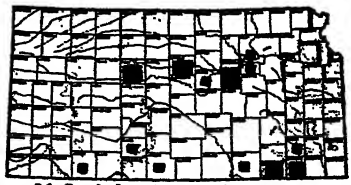
1. Asimina triloba
2. Benzoin aestivale
3. Sassafras albidum
4. Prunus besseyi
5. Juglans nigra
6. Quercus stellata
7. Bumelia lanuginosa
8. Prosopis glandulosa
9. Ilex decidua
10. Tamarix gallica
11. Cercocarpus montanus
12. Prunus virg. melanocarpa

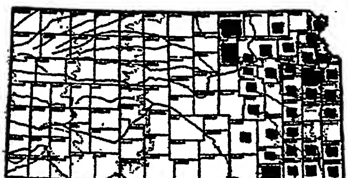
PLATE II

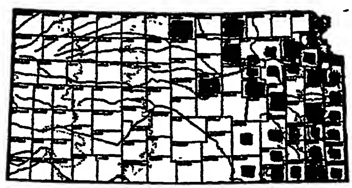

13. Cercis canadensis

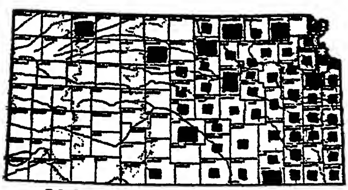

14. Gymnocladus dioica

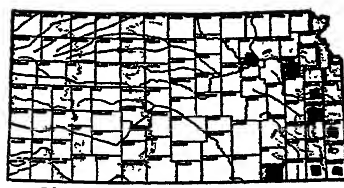

15. Platanus occidentalis


16. Sapindus drummondii

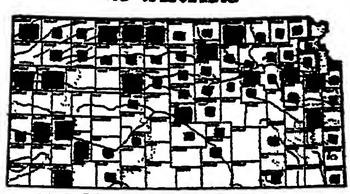

17. Carya cordiformis

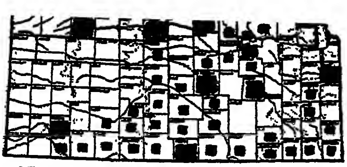

18. Quercus muhlenbergii


19. Morus rubra


20. Ptelea trifoliata


21. Ailanthus altissima


22. Salix amygdaloides


23. Prunus angustifolia watsonii

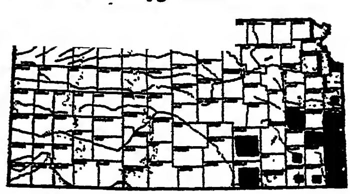
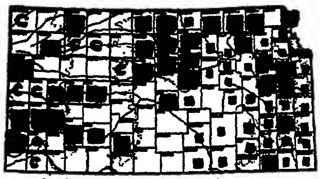
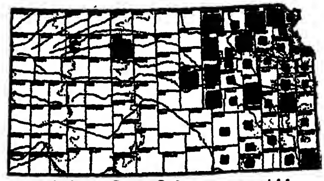

24. Prunus hortulana

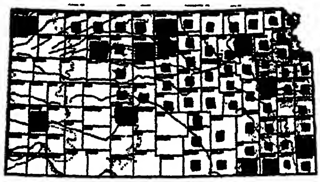
PLATE III



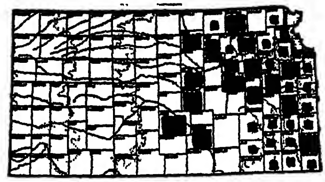
25.Gleditsia triacanthos



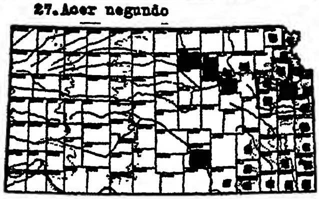
26.Aesculus glabra sargentii



27.Acer negundo



28.Acer saccharinum .



29.Quercus borealis maxima

30.Quercus macrocarpa

Kansas Botanical Notes, 1938[1]

F. C. GATES, Kansas State College, Manhattan, Kan.

Following a very early spring, three to four weeks ahead of the average, a heavy snow and cold wave, April 7, 8, killed leaves quite generally and set back vegetation to an unusual degree, so much so that even in the first week of May the hilltops, which had begun to green earlier, were again wintry in appearance.

An early frost in late September assisted in a more prompt defoliation of many trees than has been the case for several years.

A rather thorough study of the loss of trees on the Kansas State College campus at Manhattan during the years 1934 through 1937, in the latter part of the great drought, was made under the direction of Prof. L. R. Quinlan. The table below gives a summary of the totals.

TABLE of trees dead from drought

	Trees existing, 1934.	Trees dead.					Percent dead.
		1934.	1935.	1936.	1937.	Total.	
Deciduous trees..........	2,288	64	117	119	47	347	15.2
Evergreen trees..........	1,673	86	42	66	34	228	13.6
Totals..............	3,961	150	159	185	81	575	14.5

Among the conifers on the campus that showed a high percentage of loss, in fact over half the trees of that species, were *Pinus pungens* (table mountain pine) 62.5 percent loss, *Picea pungens* (Colorado blue spruce) 55 percent, *Pseudotsuga taxifolia* (Douglas fir) 51.2 percent, *Pinus banksiana* (jack pine) 50 percent, *Pinus montana mughus* (mugho pine) 50 percent, while no trees of *Juniperus chinesis* (Chinese juniper), *Juniperus chinensis pfitzeriana* (Pfitzer juniper), nor *Juniperus scopulorum* (Colorado juniper) were killed. Among the deciduous trees casualties amounting to over half of the trees of that kind on the campus included *Liriodendron tulipifera* (tulip tree) 64.3 percent, *Acer saccharum* (sugar maple) 60 percent, *Betula alba* (European white birch) 60 percent, and *Populus tremuloides* (quaking aspen) 58.3 percent. None of the following were killed in the drought. *Acer tataricum* (Tatarian maple), *Celtis laevigata* (sugarberry), *Cladrastis lutea* (yellowwood), *Crataegus tomentosa* (pear hawthorn), *Gymnocladus dioica* (Kentucky coffee tree), *Koelreuteria paniculata* (goldenrain-tree), *Morus rubra* (red mulberry), *Quercus alba* (white oak), *Quercus bicolor* (swamp white oak), *Quercus muhlenbergi* (Chinquapin oak), and *Sophora japonica* (pagoda tree).

The weed-cultivated-plant hybrid, *Aegilops cylindrica* x *Triticum aestivum*, found by C. O. Johnston in 1937 just east of Junction City, was present this

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Contribution No. 388, Department of Botany and Plant Pathology, Kansas State College.

spring in abundance and showed some recrossing. Continued study will determine how well this plant may become established. The hybrid is easily recognized by the mixture of spikelets of variable thickness on the same spike and by the great variability of awn lengths.

In 1936 a new weed appeared near Herkimer, Kan., which has now been identified as *Falcaria vulgaris,* an umbelliferous weedy plant of Europe, related to caraway. It is not, however, known whether this plant is spreading or not.

A peculiar specimen of *Euphorbia corollata was collected* in 1937, in Cheyenne county, by Mrs. John Steller. It is a remarkable western extension of this eastern plant.

Although people generally think it dangerous to water plants in the full sun, the failure of special efforts of Paul J. Kramer (Amer. Jour. Botany, 26:12, 1939) to find specific cases of such injury makes the following instance noteworthy. Late in September of 1938, just before noon, when the thermometer was high in the 90's here at Manhattan, I watered half a fair-sized bed of *Ricinus communis.* The plants were approximately eleven feet high and had at the top a series of small to three-fourth sized leaves. As far as I could tell, the leaf blades appeared to be homogeneous. Late that afternoon I noticed that the tissue between the various veins in the lower fourth of the leaf blades of those incompletely developed leaves which had been watered looked transparent. It was found that this tissue near the base of the leaves had dried up and changed color to a rather rich maroon, whereas the rest of the leaves were shades of green. In the next two days, these dried-up parts were broken to pieces by growth of the leaves, and the spectacle was presented of castor oil plant leaves with exposed veins in the lower part of the leaf. The rest of the leaf appeared normal and these leaves remained functioning until frost.

On account of the continuation of excessive drought, the number of specimens added to the State Herbarium during the year was small. They were principally a few from Saline and McPherson counties by John Hancin, a few from Atchison county from Felix Nolte, and a small collection from Brown county from Mrs. Oscar Olson.

In September, 1938, the Kansas State Herbarium was moved to a newly constructed fireproof vault in the basement of Dickens Hall, at Manhattan.

New Forms and Nomenclatorial Combinations in the Kansas Flora[1]

FRANK C. GATES, Kansas State College, Manhattan, Kan.

In preparation of a modern list of ferns and flowering plants of Kansas, a few nomenclatorial recombinations and novelties appear to be worthy of consideration. These have been gathered together in this article in order to avoid having them published first in the list itself. The trinomial in botany is usually referred to as a variety, although the designation subspecies would appear to be more reasonable.

POLYPODIACEAE

PELLAEA ATROPURPUREA GLABELLA (Mett.) F. C. Gates.
P. glabella Mett. ex Kuhn, Linnaea 36:87. 1869.

CYPERACEAE

CAREX BREVIOR MOLESTA (Mack.) F. C. Gates.
C. molesta Mackenzie. N. Amer. Flora 18:151. 1931.

TILIACEAE

TILIA **palmeri** F. C. Gates ex Bush, sp. n.

Arbor foliis juvenilis stellatis-pubescentibus inferioribus, maturis communiter glabris margine et venis-axillis exceptis, viridis nec glaucis inferioribus; floris et fructibus parvis, bractis latis.

Tree with furrowed bark and moderately slender reddish-brown glabrous twigs, with red winter buds.

Leaf blades of flowering branches broadly ovate, 6-12 cm. long, 5-10 cm. wide, becoming larger at maturity (on sprouts sometimes over 20 cm. long), acuminate, obliquely truncate or cordate to overlapping at the unsymmetrical base, coarsely mucronate-serrate or crenate with mostly rather large teeth, and large mucros, tomentose with stellate hairs in unfolding, but at maturity dark and glabrous or essentially so above, a lighter green and, except for tomentum in the leaf axils and simple or branched hairs near or at the margin, nearly or quite glabrous or sometimes sparsely pubescent beneath; cymes mostly compact, mostly few-flowered, peduncle glabrous, the free portion 2-5 cm. long, pedicels stellate pubescent; bract 8-13 cm. long, 1.5-2.5 cm. wide, spatulate, the distal portion wider, glabrous; flowers about 1 cm. (9-12 mm.) wide, sepals broadly ovate, pubescent with mostly branched hairs on the back, tomentose within, about two-thirds as long as the yellow lanceolate petals: fruit 6-8 mm. in diameter.

Bluffs and rocky woods along streams. Kentucky (Clark and Ballard counties) S. Illinois (Richland and White counties), through Missouri and northern and central Arkansas to eastern Kansas and eastern Oklahoma.

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Contribution No. 389, Department of Botany and Plant Pathology, Kansas State College.

Type: Bush 12656 from Clay county, Missouri, June 15, 1933 (sheet 1045284, Herbarium Mo. Bot. Garden) Isotype the same (sheet 79796, Herbarium Kansas State College).

Other specimens examined: (K = Kansas State; M = Missouri; and NY = New York Bot. Gardens):

Kansas:

Linn county in 1887. Collector unknown (K).

Morris county, May, 1896. T. Havens (K).

Geary county, September, 1933. F. C. Gates, 17525 (K).

Missouri:

Clay county, June, 1933. B. F. Bush, 12656 (K, M), 12658 (K).

Saline county, June 1933. B. F. Bush, 12647 (K, M), 12649 (M), 12651 (M), 12654 (M).

Jackson county, in 1905, 1927, 1932. B. F. Bush, 3042, 11380A, 12511B (NY).

Dent county, July, 1931. John H. Kellogg, 25641 (NY).

Texas county, July, 1931. John H. Kellogg, 25654 (NY).

Arkansas: Izard county, April, 1929. E. J. Palmer, 35575 (M, NY).

This species differs from *Tilia americana* L., the only other Tilia native in Kansas, in the heavy stellate-pubesence of the lower side of the unfolding leaves (instead of glabrous or nearly so), in retaining hairs at least at and near the margin in maturity (not glabrous), smaller flowers, 9-12 mm. wide (instead of 12-15 mm.) and smaller fruits, 6-8 mm. diameter (instead of 8-10 mm.). From *Tilia floridana* Small, as described by Bush in Small's "Manual of the Southeastern Flora," 1933, in which it has been submerged, *T. palmeri* differs in having the leaves green beneath (not glaucous), the peducle glabrous (not hairy), and the bracts broad (not narrow).

In the course of studies by B. F. Bush upon Tilia for inclusion in Small's "Manual of the Southeastern States" and the proposed manual for the south central states, certain herbarium sheets were labeled *Tilia palmeri* Bush. Publication of this name, however, was to have taken place in the proposed manual, but death overtook both men before this was done. In publishing an up-to-date list of Kansas woody plants (Trans. Kansas Acad. of Science 41: 99-118. 1938) the present author inadvertently included *Tilia palmeri* Bush, which, in the absence of publication, is there a nomen nudum.

To permit proper inclusion of this tree in the forthcoming list of Kansas plants the description above was drawn up under the name selected by Mr. Bush in honor of Mr. E. J. Palmer from material in the herbaria of Kansas State College, Missouri Botanical Garden, and New York Botanical Garden kindly put at my disposal, and the range from this material together with personal notes kindly made by E. J. Palmer from material in the Arnold Arboretum.

RUTACEAE

ZANTHOXYLUM AMERICANUM f. **armatius** F. C. Gates forma nova.

Ramuli rachisque bene armatis.

Young branches, twigs and leaf rachises covered with spines in addition to the pair normally at each node in the species.

Shrub in thickets in prairies.

Kansas: Riley (type F. C. Gates 16503, collected Feb. 11, 1931, in Herbarium of Kansas State College) and Marshall counties.

BRASSICACEAE

DESCURAINIA INTERMEDIA (Rydb.) F. C. Gates.
Sophia intermedia Rydb. Mem. N. Y. Bot. Gard. 1:184. 1900.

DESCURAINIA MAGNA (Rydb.) F. C. Gates.
Sophia magna Rydb. Bull. Torr. Bot. Club 34:436. 1907.

DESCURAINIA PINNATA BRACHYCARPA (Richardson) F. C. Gates.
Sisymbrium brachycarpon Richardson in Frankl. Narr. 1st Journ. App. 744, year?

DESCURAINIA RICHARDSONIANA (Sweet) F. C. Gates.
Sophia richardsoniana (Sweet) Rydb.
Sisymbrium richardsoniana Sweet. Hort. Brit. ed. 2:30. 1830.

CHENOPODIACEAE

CHENOPODIUM LEPTOPHYLLUM PRATERICOLA (Rydb.) F. C. Gates.
Chenopodium pratericola Rydb. Bull. Torr. Bot. Club 39:310. 1912.

SOLANACEAE

SOLANUM NIGRUM INTERIUS (Rydb.) F. C. Gates.
Solanum interius Rydb. Bull. Torr. Bot. Club 31:641. 1904.

OLEACEAE

FRAXINUS PENNSYLVANICA CAMPESTRIS (Britton) F. C. Gates.
Fraxinus campestris Britton. N. Amer. Trees: 799. 1908.

APOCYNACEAE

APOCYNUM CANNABINUM ALBUM (Greene) F. C. Gates.
Apocynum album Greene. Pittonia 3:230. 1897.

FABACEAE

ASTRAGALUS GRACILIS PARVIFLORUS (Pursh) F. C. Gates.
Dalea parviflora Pursh. Fl. Am. Sept. 474. 1814.
Astragalus parviflorus MacM. Meta. Minn. 325. 1892.
Microphacos parviflorus (Pursh) Rydb.

ASTRAGALUS LONGIFOLIUS (Pursh) F. C. Gates.
Psoralea longifolia Pursh. Fl. Am. Sept. 741. 1814.
Phaca longifolia Nutt. T. & G. Fl. N. A. 1:346. 1838.

ASTRAGALUS LOTIFLORUS CRETACEUS (Buckl.) F. C. Gates.
Phaca cretacea Buckl. Proc. Acad. Sci. Phila. 1861:452. 1862.
(*Astragalus cretaceus* Boiss—a Syrian plant would prevent transfer as a species).

OENOTHERACEAE

OENOTHERA MISSOURIENSIS f. **elongata** F. C. Gates. f. nov.
Ab specie differt fructus plus 2 longiore ob late.
A sprawling to somewhat ascending hemicrytophyte similar to *Oenothera missouriensis typica,* but with the mature fruit including the wings 94-115 x 40-45 mm., the length averaging about 2.5 times the width instead of decidedly less than twice (equal in some specimens) in the species.

Rocky prairie in Wingfield township, Geary Co., Kansas. Type F. C. Gates 18668, collected Oct. 3, 1935, deposited in the Kansas State Herbarium at Manhattan, Kan.

OENOTHERA SERRULATA OBLANCEOLATA (Rydb.) F. C. Gates.
Meriolix oblanceolata Rydb. Type Rydberg & Imler 737 in N. Y. Bot. Gard. Brittonia 1:93. 1931.

OENOTHERA TRILOBA WATSONI (Britt.) F. C. Gates.
Lauvauxia watsoni Britton. Mem. Torr. Bot. Club 5:235. 1894.

GAURA COCCINEA GLABRA (Lehm.) F. C. Gates.
G. glabra Lehm. in Hook. Fl. Bor. Am. 1:209.

GAURA COCCINEA PARVIFOLIA (Torr.) F. C. Gates.
G. parvifolia Torr. in Ann. Lyc. N. York, 2:201. 1828.

ANACARDIACEAE

RHUS TOXICODENDRON NEGUNDO (Greene) F. C. Gates.
Toxicodendron negundo Greene. Leaflets Bot. Abs. 1:117. 1905.

"COMPOSITAE"

XIMENESIA ENCELIOIDES EXAURICULATA (Robinson & Greenm.) F. C. Gates.
Verbesina encelioides exauriculata Robinson & Greenm. Proc. Amer. Acad. 34:544. 1899.

ASTER ERICOIDES BATESII (Rydb.) F. C. Gates.
Aster batesii Rydb. Brittonia 1:102. 1931.

ASTER ERICOIDES F. POLYCEPHALUS (Rydb.) F. C. Gates.
Aster polycephalus Rydb. Bull. Torr. Bot. Club 33:153. 1906.

ASTER ERICOIDES STRICTICAULIS (T. & G.) F. C. Gates.
Aster stricticaulis T. & G. Torrey & Gray. Flora N. Am. 2:125. 1842.

EUTHAMIA GRAMINIFOLIA NUTTALLII (Greene) F. C. Gates.
Euthamia nuttallii Greene. Pittonia 5:73. 1902.
Solidago nuttallii (Greene) Bush. Am. Midl. Nat. 5:168. 1918.

LIATRIS SQUARROSA GLABRATA (Rydb.) F. C. Gates.
Liatris glabrata Rydb. Brittonia 1:98. 1931.

LIATRIS SQUARROSA HIRSUTA (Rydb.) F. C. Gates.
Liatris hirsuta Rydb. Brittonia 1:98. 1931.

ARTEMISIA VULGARIS CARRUTHI (Wood) F. C. Gates.
Artemisia carruthi Wood in Carruth, Trans. Kans. Acad. Sci. 5:51. 1877.
Artemisia wrighti A. Gray. Proc. Am. Acad. 19:48. 1883.
Artemisia vulgaris wrighti (A. Gray) Hall & Clements.
Artemisia kansana Britton. Type from Lane County, Kan.
Even Hall and Clements say "carruthi Wood is the oldest name but not well established." It was published in the state Academy TRANSACTIONS six years the earliest, is recognizable and is, I believe, entitled to the primary consideration.

Flora of Saline County: Ferns and Flowering Plants

JOHN HANCIN, Salina, Kan.

Originally the piece of land in central Kansas, 24 x 30 miles in extent, called Saline county, was typical grassland, composed of broad valleys, flat prairie, and rolling upland, without salt-marshes, lakes, dunes, cañons, badlands, mountains or other striking features. The vegetation consisted mainly of the dominant grasses and their associated herbs, a few small shrubs like roses and lead plants, a fringe of trees beside the larger streams and an occasional willow and cottonwood, some plum thickets, and a little dogwood and buttonbush along the smaller watercourses.

Notwithstanding the apparent monotonous uniformity of the terrain, the region contains a large assortment of habitats capable of supporting a rich and varied flora. From place to place the soil itself varies in depth, texture, composition, and substrata—light sandy soil, heavy gumbo, and various loams occupying extensive areas. Dakota sandstone is the only important native stone. Small outcrops of gypsum occur in the eastern part, near Gypsum Creek. There is no genuine limestone, but at some places the subsoil contains an abundance of lime concretions. On the level prairie alkali spots and swales cater to the special needs of certain plants. Dry, stony hills accommodate xerophytes. On the sides of hills and at their bases, in many places, unfailing springs form diminutive bogs and marshes where aquatics thrive. Moist shaded sandstone ledges furnish homes for mosses, ferns, and liverworts. In favorable situations along streams the wooded tracts are extensive enough to produce a forest floor suitable for a sylvan flora.

At present nearly all the arable land is in cultivation, with most of the native plants destroyed. Even on unbroken prairie the vegetation has been profoundly changed by overgrazing. But enough surface remains undisturbed, in the form of springy places, stone outcrops, and other waste lands so that probably very few native species have been utterly exterminated. Individuals have perished, but species have survived. On the other hand, farming operations, travel, and commerce have been instrumental in introducing a multitude of exotic plants. New ones are still arriving and making themselves at home. *Aegilops cylindrica* and *Lepidium perfoliatum* appeared quite recently and are spreading rapidly. *Myriophyllum proserpinacoides* was found in a spring-fed pool on a hillside in a pasture. It would be interesting to know the history of its migration.

Settlers began to locate in Saline county in 1858. Let us note what has happened, botanically, to some of the things they planted for use and ornament. Of woody plants, matrimony vine and trumpet creeper persist on abandoned homesites. Ailanthus, mulberry, black locust, and osage orange have escaped and are established. Occasional seedlings of peach, apricot, perfumed cherry, soft maple, catalpa, and sycamore have migrated into favorable places and grown to maturity. Pear, white poplar, English elm, and persimmon spread by suckers. Soapberry and crack willow also reproduce, but we have

not ascertained in what way. In recent years we have noticed many seedlings of Tamarix, Koelreuteria, Ohio buckeye, and Austrian pine which survive the winters and promise to make good. Hard maple and basswood fruit abundantly and the seeds germinate freely, but the seedlings invariably die. Among grasses, millet, Sudan grass, orchard grass, smooth brome grass, and meadow fescue seem to have become permanent members of our flora. The garden leek, asparagus, dill, bouncing Bet, ox-eye daisy, iris, larkspur, portulaca, bachelor's buttons, and star-of-Bethlehem have escaped from gardens.

The material on which the subjoined list is mainly based has accumulated as a result of collecting by the author at spare times during the last few years, prompted largely by a desire to coöperate in preparing an up-to-date check list of the plants of Kansas. No thorough survey has been made. Over half of the county is wholly unexplored and very little of the rest has been worked exhaustively. Most collecting was done at a few small stations chosen by reason of their accessibility and their diversity of ecological factors, with occasional trips to other parts. Doubtless many additional species await discovery. Some things definitely known to grow here remain unidentified, partly for lack of satisfactory material, and partly because certain prominent characters are not mentioned in the manuals.

Space forbids detailed annotation on the habitat, associates, distribution, and economic status of species, but a few notes are scattered thorough this introductory statement, and on the accompanying list under the names to which they pertain. Of the fifty worst weeds of the United States named in a government publication, over thirty are found here. About seventy-five species are used in medicine, and about as many are poisonous. Twenty-odd species of our woody plants bear edible fruit. Natural hybrids seem to be rare. A hybrid Baptisia and two hybrids of Tradescantia are all we have seen. Albinos occur in several species, of which *Salvia pitcheri, Vernonia interior, Liatris punctata, Callirhoe involucrata, Baptisia australis,* and *Schrankia uncinata* may be mentioned. Situated near the border where the flora of the prairies meets the high plains flora, Saline county contains many plants growing at the limits of their range, and some of them in adjusting themselves to a changing environment develop interesting ecads. For example, we have black walnut trees with fully matured and entirely sound nuts only a half inch in diameter.

We have drawn upon all available sources of information in preparing the list. Names mostly follow the International Rules. Trinominals are used for subspecies and important variations. Minor forms are omitted. There would be five or more species in Chenopodium alone if we were to recognize all proposed segregates. Only plants which grow of their own accord are enumerated. Volunteers of cultivated plants are excluded unless they reproduce and maintain themselves like wildlings. There is a school which holds that a species is a group of organisms, similar in structure and inhabiting a definite area, and that individuals found off their reservation should not be recognized. We have never accepted the idea of making range a part of the species concept, and for this reason waifs are included on our list. When we find a solitary plant growing spontaneously, in perfect health, far from its reported range, we have no way of knowing whether it is a waif or a pioneer. Its status can be established only by observing whether it is able to ecize. Many of our most

abundant and troublesome weeds are vagabonds from Europe and Asia. Should we ignore them when making a check list? It is a custom of some to assume that if a species has been collected at given points, it will also occur, within reasonable limits, in like habitats at intermediate points. This is not our policy. Every name on our list is based upon the examination of an identifiable specimen taken within the county. Plants not found by the author but represented by authenticated specimens in herbaria are marked with an asterisk.

Specimens and data of everything found have been forwarded to the Botany Department of Kansas State College, Manhattan, Kan., for the State Herbarium. Credit is due to Dr. F. C. Gates for the painstaking work of verifying and correcting determinations and bringing the nomenclature into conformity with present usage.

CHECK LIST

FERNS

Ophioglossaceae

Botrichium virginianum
  Rare.

Polypodiaceae

Onoclea sensibilis
Woodsia obtusa
Dryopteris thelypteris
Dryopteris marginalis
  Rare.
Pellaea atropurpurea glabella

Marsileaceae

Marsilea vestita

Equisetaceae

Equisetum arvense
Equisetum kansanum
Equisetum laevigatum

CONIFERS

Pinaceae

Juniperus virginiana
  Exterminated by early settlers. Returned from planted trees.
Pinus nigra austriaca

FLOWERING PLANTS

Alismaceae

Echinodorus cordifolius
Lophotocarpus calycinus
Sagittaria ambigua
Sagittaria brevirostra
Sagittaria latifolia
Sagittaria longiloba

Typhaceae

Typha latifolia

(*Zannichelliaceae*)

Potamogeton americanus
  Rare.
Potamogeton dimorphus
Potamogeton foliosus
Potamogeton pusillus
Zannichellia palustris

Liliaceae

Allium canadense
Allium cernuum
  A waif.
Allium mutabile
  Flowers either white or tinged with rose. Throughout. A form with flowers only white, and fragrant, on sandy upland only.
Allium nuttallii
Allium perdulce
Allium porrum
Allium vineale
Androstephium coeruleum
Asparagus officinalis
Erythronium albidum mesochoreum
Nothoscordum bivalve
Ornithogalum umbellatum
Polygonatum commutatum
Smilax hispida
Smilax lasioneuron
Yucca glauca
Zygadenus nuttallii
  Blooms in profusion, year after year, on a barren hill southeast of Bridgeport, and only there.

Pontederiaceae

Heteranthera limosa
Heteranthera peduncularis

Commelinaceae

Commelina communis
Commelina crispa
Commelina erecta?
Commelina virginica*

FLOWERING PLANTS—CONTINUED

Tradescantia bracteata
Tradescantia canaliculata
Tradescantia occidentalis
Tradescantia occidentalis × canaliculata
Tradescantia tharpii
Tradescantia tharpii × bracteata

Juncaceae

Juncus acuminatus
Juncus aristulatus
Juncus diffusissimus
Juncus dudleyi
Juncus interior
Juncus kansanus
Juncus macer
Juncus marginatus
Juncus torreyi

Araceae

Acorus calamus
Arisaema dracontium

Lemnaceae

Lemna minima
Lemna perpusilla
Spirodela polyrhiza

Cyperaceae

Carex aggregata
Carex annectens xanthocarpa
Carex austrina
Carex bicknellii
Carex blanda
Carex brevior
Carex bushii
Carex darisii
Carex emoryi
Carex gravida
Carex gravida lunelliana
Carex grisea
Carex heliophila
Carex hystricina
Carex laeviconica
Carex lanuginosa
Carex leavenworthii
Carex meadii
Carex scoparia
Carex stipata
Carex vulpinoidea
Cyperus acuminatus
Cyperus esculentus
Cyperus ferruginescens
Cyperus filiculmis
Cyperus houghtoni
Cyperus inflexus
Cyperus rivularis
Cyperus schweinitzii
Cyperus strigosus
Eleochcaris compressa
Eleocharis engelmanni
Eleocharis macrostachya
Eleocharis obtusa
Eleocharis wolfii
Fimbristylis puberula
Fuirena simplex
Scirpus americanus
Scirpus atrovirens
Scirpus fluviatilis
Scirpus hallii
Scirpus lineatus
Scirpus pallidus
Scirpus validus

Poaceae

Aegilops cylindrica
Agropyron smithii
Agrostis hiemalis
Agrostis alba
Alopecurus carolinianus
Andropogon furcatus
Andropogon hallii
Andropogon saccharoides
Andropogon scoparius
Andropogon virginicus
Aristida basiramea
Aristida curtissii
Aristida longiseta
Aristida longiseta robusta
Aristida oligantha
Aristida purpurascens
Aristida purpurea*
Bouteloua curtipendula
Boutelous gracilis
Bouteloua hirsuta
Bromus catharticus
Infrequent
Bromus inermis
Bromus japonicus
Bromus purgans
Bromus secalinus
Bromus tectorum
Buchloe dactyloides
Cenchrus pauciflorus
Chloris verticillata
Cinna arundinacea
Cynodon dactylon
Dactylis glomerata
Diarrhena americana
Digitaria sanguinalis
Distichlis stricta
Echinochloa crusgalli
Echinochloa crusgalli mitis
Eleusine indica
Elymus canadensis brachystachys
Elymus canadensis robustus
Elymus villosus
Elymus virginicus
Eragrostis barrelieri
Eragrostis cilianensis
Eragrostis hypnoides

FLOWERING PLANTS—CONTINUED

Eragrostis pectinacea
Eragrostis poaeoides
Eragrostis reptans
Eragrostis secundiflora
Eragrostis spectabilis
Eragrostis trichodes
Eriochloa contracta
Festuca elatior
Festuca octoflora
Festuca ovina
Glyceria striata
Hordeum jubatum
Hordeum pusillum
Koeleria cristata
Leersia oryzoides
Leersia virginica
Leptochloa fascicularis
Leptochloa filiformis
Leptoloma cognatum
Lolium perenne
Muhlenbergia asperifolia
Muhlenbergia brachyphylla
Muhlenbergia cuspidata
Muhlenbergia foliosa
Muhlenbergia mexicana
Muhlenbergia racemosa
Muhlenbergia schreberi
Muhlenbergia sobolifera
Muhlenbergia sylvatica
Panicum agrostoides
Panicum capillare
Panicum dichotomiflorum
Panicum hillmani
Panicum huachucae
Panicum huachucae fasciculatum
Panicum perlongum
Panicum pseudopubescens
Panicum scribnerianum
Panicum villosissimum
Panicum virgatum
Paspalum stramineum
Phalaris arundinacea
Phalaris canariensis
Phalaris caroliniana
Phleum pratense
Poa annua*
Poa arida
Poa pratensis
Schedonnardus paniculatus
Setaria geniculata
Setaria italica
Setaria lutescens
Setaria viridis
Sorghastrum nutans
Sorghum halepense
Sorghum vulgare sudanense
Spartina pectinata
Sphenopholis obtusata
Sporobolus asper
Sporobolus asper hookeri
Sporobolus clandestinus
Sporobolus cryptandrus
Sporobolus neglectus
Sporobolus pilosus*
Sporobolus vaginiflorus
Stipa spartea
Triodia flava
Triplasis purpurea
Tripsacum dactyloides
Uniola latifolia

Iridaceae

Iris germanica
Sisyrinchium campestre

Ranunculaceae

Anemone caroliniana
Clematis fremontii
Clematis pitcheri
Delphinium ajacis
Delphinium virescens
Myosurus minimus
Ranunculus abortivus
Ranunculus longirostris
Ranunculus sceleratus
Thalictrum dasycarpum

Menispermaceae

Menispermum canadense

Ceratophyllaceae

Ceratophyllum demersum

Malvaceae

Abutilon theophrasti
Callirhoe alceoides
Callirhoe involucrata
Hibiscus trionum
Malva neglecta
Malvastrum coccineum
Sida spinosa

Ulmaceae

Celtis occidentalis
Celtis occidentalis crassifolia
Celtis reticulata
Celtis reticulata vestita
Ulmus americana
Ulmus campestris
Ulmus fulva

Moraceae

Cannabis sativa
Humulus lupulus
Maclura pomifera
Morus alba
Morus rubra

Urticaceae

Boehmeria cylindrica
Parietaria pennsylvanica
Pilea pumila
Urtica procera

FLOWERING PLANTS—CONTINUED

Geraniaceae
Geranium carolinianum

Oxalidaceae
Oxalis corniculata
Oxalis stricta
Oxalis violacea

Linaceae
Linum campactum
Linum sulcatum

Zygophyllaceae
Kallstroemia intermedia
Tribulus terrestris

Simarubaceae
Ailanthus altissimus

Polygalaceae
Polygala incarnata
Polygala verticillata

Euphorbiaceae
Acalypha gracilens
Acalypha ostryaefolia
Acalypha virginica
Chamaesyce glyptosperma
Chamaesyce humistrata
Chamaesyce hyssopifolia
Chamaesyce maculata
Chamaesyce petaloidea
Chamaesyce serpens
Chamaesyce stictospora
Croton capitatus
Croton glandulosus
Croton monanthogynus
Croton texensis
Galarrhoeus obtusatus
Lepadena marginata
Poinsettia dentata
Poinsettia heterophylla
Tragia nepetaefolia
Zygophyllidium hexagonum

Callitrichaceae
Callitriche heterophylla

Hypericaceae
Hypericum mutilum

Violaceae
Viola arvensis
A recent invader.
Viola missouriensis
Viola nephrophylla
Viola papilionacea
Viola pedatifida
Viola rafinesquii
Viola retusa

Papaveraceae
Argemone intermedia

Furmariaceae
Corydalis campestris
Corydalis montana

Capparidaceae
Polanisia trachysperma

Brassicaceae
Barbarea vulgaris
Rare.
Brassica arvensis
Brassica campestris
Brassica juncea
Brassica nigra
Camelina microcarpa
Capsella bursa-pastoris
Cardamine pennsylvanica
Conringia orientalis
Draba reptans
Draba reptans micrantha
Erysimum asperum
Rare.
Erysimum repandum
Hesperis matronalis
Lepidium densiflorum
Lepidium draba
Lepidium perfoliatum
Lepidium oblongum
Lepidium virginicum
Mathiola bicornis
A few plants on roadside, 1939.
Naturtium officinale
Rorippa palustris
Rorippa sessiliflora
Rorippa sinuata
Sisymbrium altissimum
Sisymbrium officinale
Sophia incisa
Sophia multifida
Sophia pinnata
Thlaspi arvense

Caryophyllaceae
Arenaria serpyllifolia
Cerastium brachypodum
Cerastium vulgatum
Lychnis alba
Saponaria officinalis
Silene antirrhina
Stellaria media
Vaccaria vulgaris
Seems to fade out of our flora sometimes, and later, return.

Illecebraceae
Paronychia jamesii

Elatinaceae
Bergia texana

Portulacaceae
Claytonia virginica
Portulaca grandiflora
Portulaca oleracea
Portulaca parvula
Talinum calycinum

FLOWERING PLANTS—CONTINUED

Aizoaceae

Mollugo verticillata

Tamaricaceae

Tamarix gallica

Salicaceae

Populus alba
Populus sargentii
Populus deltoides (P. virginiana)
Salix amygdaloides
Salix cordata
Salix fragilis
Salix interior
Salix nigra

Phytolaccaceae

Phytolacca decandra

Amaranthaceae

Acnida tamariscina
Amaranthus blitoides
Amaranthus graecizans
Amaranthus hybridus
Amaranthus palmeri
Amaranthus powellii
Amaranthus retroflexus
Amaranthus torreyi
Froelichia campestris
Froelichia gracilis

Chenopodiaceae

Atriplex argentea
Atriplex hortensis
Chenopodium album
 Extremely variable.
Chenopodium ambrosioides
Chenopodium boscianum
Chenopodium hybridum
Chenopodium leptophyllum
 Several forms, pratericola being commonest.
Cycloloma atriplicifolium
Kochia scoparia
Monolepis nuttalliana
Salsola pestifer

Polygonaceae

Eriogonum annuum
Fagopyrum esculentum*
Polygonum aviculare
 (including so called var. augustissimum)
Polygonum buxiforme
Polygonum coccineum pratincolum
Polygonum convolvulus
Polygonum erectum
Polygonum hydropiperoides
Polygonum lapathifolium
Polygonum longistylum
Polygonum pennsylvanicum
Polygonum persicaria
Polygonum persicarioides
Polygonum punctatum
Polygonum ramosissimum
Polygonum scandens
Polygonum tenue
Polygonum virginianum
Rumex acetosella
Rumex altissimus
Rumex crispus
Rumex obtusifolius
Rumex occidentalis
Rumex venosus

Nyctaginaceae

Mirabilis albida
Mirabilis carletoni
Mirabilis linearis
Mirabilis nyctaginea

Primulaceae

Anagallis arvensis*
Androsace occidentalis

Plantaginaceae

Plantago elongata*
Plantago lanceolata
Plantago major
Plantago purshii
 Including long-bracted forms.
Plantago rugelii
Plantago virginica

Ebenaceae

Diospyros virginiana

Convolvulaceae

Convolvulus sepium americanus
Convolvulus arvensis
Convolvulus interior
Evolvulus nuttallianus
Ipomoea hederacea
Ipomoea lacunosa
Ipomoea leptophylla
Ipomoea purpurea
Ipomoea spp.
 Occasional plants with leaves like I. hederacea and flowers like I. purpurea, and others with the order reversed. Are they hybrids? or mutants?
Quamoclit coccinea

Cuscutaceae

Cuscuta cuspidata
Cuscuta indecora longisepala
Cuscuta indecora neuropetala
Cuscuta paradoxa
Cuscuta pentagona calycina
Cuscuta pentagona typica
Cuscuta polygonorum

Hydrophyllaceae

Ellisia nyctelea

Boraginaceae

Lappula occidentalis
Lappula virginiana
Lithospermum arvense
Lithospermum gmelini

FLOWERING PLANTS—Continued

Lithospermum linearifolium
Myosotis virginica
Onosmodium occidentale

Solanaceae

Datura metel
Datura stramonium
Physalis heterophylla
Physalis longifolia
Physalis pumila*
Physalis virginiana
Lycium halimifolium
Solanum carolinense
Solanum elaeagnifolium
Solanum nigrum
Solanum rostratum
Solanum torreyi

Oleaceae

Fraxinus pennsylvanica
Fraxinus pennsylvanica campestris
Fraxinus pennsylvanica lanceolata

Apocynaceae

Apocynum cannabinum
Apocynum pubescens
Apocynum sibiricum

Ascelepiadaceae

Acerates angustifolia
Acerates lanuginosa
Acerates viridiflora
Variable in leaf-form.
Asclepias amplexicaulis
Ascelepias incarnata
Ascelepias kansana
Asclepias pumila
Asclepias speciosa
Ascelpias sullivantii
Asclepias syriaca
Asclepias tuberosa
Asclepias verticillata
Asclepiodora viridis
Gonolobus laevis

Scrophulariaceae

Castilleja sessiliflora
Gerardia aspera
Gerardia tenuifolia macrophylla
Leucospora multifida
Linaria texana
Linaria vulgaris
Lindernia anagallidea
Lindernia dubia
Macuillamia rotundifolia
Penstemon caudatus
Penstemon cobaea
Penstemon grandiflorus
Scrophularia leporella
Scrophularia marylandica
Verbascum blattaria
Verbascum thapsus
Veronica arvensis
Veronica didyma
Veronica peregrina xalapensis

Bignoniaceae

Catalpa speciosa
Tecoma radicans

Martyniaceae

Proboscidea louisianica

Orobanchaceae

Myzorrhiza ludoviciana

Acanthaceae

Ruellia caroliniensis (R. ciliosa)
Ruellia strepens

Phrymaceae

Phryma leptostachya

Verbenaceae

Lippia cuneifolia
Lippia lanceolata
Verbena bipinnatifida
Verbena bracteosa
Verbena hastata
Verbena stricta
Verbena urticaefolia

Lamiaceae

Agastache nepetoides
Glecoma hederacea
Hedeoma hispida
Lamium amplexicaule
Leonurus cardiaca
Lycopus americanus
Lycopus virginicus
Marrubium vulgare
Monarda citriodora
Monarda mollis
Monarda punctata occidentalis
Nepeta cataria
Prunella vulgaris
Salvia pitcheri
Salvia pratensis
Once locally abundant in a pasture near Salina. Exterminated by cultivation.
Salvia reflexa
Scutellaria australis
Scutellaria lateriflora
Teucrium canadense

Rosaceae

Agrimonia parviflora
Geum canadense camporum
Potentilla monspeliensis
Potentilla pentandra
Rosa blanda
Rosa bourgeauiana
Ross suffulta
Rubus flagellaris occidualis
Rubus occidentalis
Rubus ostryifolius

Malacaceae

Pyrus communis

FLOWERING PLANTS—CONTINUED

Prunaceae

Prunus americana
Prunus angustifolia watsonii
Prunus armeniaca
Prunus besseyi
Prunus gracilis
Prunus mahaleb
Prunus persica
Prunus virginiana

Mimosaceae

Desmanthus illinoensis
Desmanthus leptolobus
Schrankia uncinata

Cassiaceae

Cassia marylandica
Cercis canadensis
Chamaecrista fasciculata
Gleditsia triacanthos
Gymnocladus dioica

Fabiaceae

Acmispon americana
Amorpha canescens
Amorpha fruticosa (A. fragrans).
Amphicarpa bracteata comosa
Apios americana (A. tuberosa)
Astragalus crassicarpus
Astragalus lotiflorus
Astragalus plattensis
Baptisia australis
Baptisia leucophaea
Baptisia leucophaea x australis
Crotalaria sagittalis
Dalea aurea
Dalea enneandra
Desmodium acuminatum
Desmodium canadense
Desmodium canescens
Desmodium illinoense
Desmodium paniculatum pubens
Desmodium sessilifolium
Glycyrrhiza lepidota
Lespedeza capitata
Medicago lupulina
Medicago sativa
Melilotus alba
Melilotus officinalis
Oxytropis lamberti
Petalostemum candidum
Petalostemum occidentale (P. oligophyllum)
Petalostemum purpureum
Petalostemum villosum
Psoralea argophylla
Psoralea digitata
Psoralea esculenta
Psoralea floribunda
Psoralea tenuiflora
Robinia pseudoacacia
Sophora sericea
Strophostyles helvola
Strophostyles leiosperma
Tephrosia leucosericea
Trifolium pratense
Trifolium repens
Trifolium resupinatum
Vicia sparsifolia

Grossulariaceae

Ribes missouriense
Ribes odoratum

Crassulaceae

Penthorum sedoides

Platanaceae

Platanus occidentalis

Lythraceae

Ammannia auriculata
Ammannia coccinea
Lythrum alatum
Peplis diandra

Oenotheraceae

Epilobium coloratum
Gaura coccinea
Gaura parviflora
Isnardia palustris
Jussinea diffusa
Ludwigia alternifolia
Oenothera grandis
Rare.
Oenothera laciniata
Oenothera rhombipetala
Rare.
Oenothera serrulata
Oenothera speciosa
Oenothera strigosa
Oenothera triloba
Oenothera triloba watsoni
Stenosiphon linifolium

Haloragidaceae

Myriophyllum proserpinacoides

Cactaceae

Neomamillaria similis
Neomamillaria vivipara
Opuntia camanchica
Opuntia humifusa
Opuntia macrorhiza
Optunia tortispina
Longer spines, smaller joints, earlier blooming than our other prickly pears.

Loasaceae

Mentzelia decapetala
Mentzelia obligosperma

Cucurbitaceae

Micrampelis lobata
Pepo foetidissima
Sicyos angulatus

Rhamnaceae

Ceanothus ovatus

FLOWERING PLANTS—CONTINUED

Vitaceae
Parthenocissus hirsuta
Parthenocissus quinquefolia
Parthenocissus vitacea
Vitis vulpina

Celastraceae
Celastrus scandens
Euonymus atropurpureus

Sapindaceae
Koelreuteria paniculata
Sapindus drummondii

Aesculaceae
Aesculus glabra

Aceraceae
Acer negundo
Acer saccharinum

Anacardiaceae
Rhus glabra
Rhus toxicodendron radicans
Rhus trilobata serotina

Juglandaceae
Juglans nigra

Fagaceae
Quercus macrocarpa
Quercus muhlenbergii

Santalaceae
Comandra pallida

Ammiaceae
Anethum graveolens
Berula erecta
Chaerophyllum procumbens
Cicuta maculata
Conium maculatum
Cultivated and running wild.
Daucus carota
Eryngium leavenworthii
Many plants flourished on railroad ballast a few years, then vanished to reappear.
Lomatium dancifolium
Lomatium orientale
Pastinaca sativa
Sanicula canadensis
Spermolepis patens

Cornaceae
Cornus asperifolia

Rubiaceae
Cephalanthus occidentalis
Galium aparine
Galium circaezans
Houstonia angustifolia
Houstonia minima

Caprifoliaceae
Sambucus canadensis
Symphoricarpos orbiculatus

Campanulaceae
Specularia leptocarpa
Specularia perfoliata

Lobeliaceae
Lobelia siphilitica
Lobelia splendens

"Composites"

Helianthaceae
Actinomeris alternifolia
Berlandiera texana
Bidens bipinnata
Bidens frondosa
Bidens glaucescens
Bidens vulgata puberula
Coreopsis tinctoria
Dracopsis amplexicaulis
A waif.
Echinacea angustifolia
Eclipta alba
Helianthus annuus
Helianthus besseyi
Helianthus grosseserratus
Helianthus laetiflorus
Helianthus maximiliani
Helianthus mollissimus
Helianthus petiolaris
Helianthus rigidus
Helianthus salicifolius
A waif.
Helianthus severus
Helianthus tuberosus
Parthenium hysterophorus
Ratibida columnifera
Ratibida tagetes
Rudbeckia hirta
Silphium laciniatum
Silphium speciosum
Thelesperma gracile
Ximenesia exauriculata

Ambrosiacecae
Ambrosia coronopifolia
Ambrosia elatior
Ambrosia trifida
Iva ciliata
Iva xanthifolia
Rare.
Xanthium pennsylvanicum
Xanthium italicum

Heleniaceae
Boebera papposa
Helenium tenuifolium
A single plant.
Hymenopappus scabiosaeus

Inulaceae
Antennaria campestris
Gnaphalium obtusifolium
Gnaphalium purpureum

Asteraceae
Amphiachyris dracunculoides
Aster ericoides (A. multiflorus).
Aster ericoides batesii
Aster ericoides prostratus (A. exiguus)

FLOWERING PLANTS—CONCLUDED

Aster exilis
Aster fendleri*
Aster oblongifolius
Aster paniculatus
Aster sericeus
Boltonia latisquama
Chrysopsis angustifolia
Chrysopsis foliosa
Chrysopsis hirsutissima
Chrysopsis hispida
Chrysopsis imbricata
Chrysopsis stenophylla
Erigeron annuus
Erigeron ramosus
Euthamia graminifolia
Euthamia gymnospermoides
Grindelia squarrosa
Heterotheca subaxillaris
Isopappus divaricatus
Leptilon canadense
Leptilon divaricatum
Leucelene ericoides
Prionopsis ciliata
Sideranthus spinulosus
Solidago altissima
Solidago canadensis
Solidago canadensis gilvocanescens
Solidago dumetorum
Solidago glaberrima
  Variable in habit and leaf-form, one called var. moritura.
Solidago mollis
Solidago nemoralis
  Several forms.
Solidago petiolaris
Solidago rigida
Solidago serotina
Solidago speciosa angustata (S. rigidiuscula)

Vernoniaceae

Vernonia fasciculata
Vernonia interior

Eupatoriaceae

Eupatorium altissimum
Eupatorium perfoliatum
Eupatorium rugosum (E. urticaefolium)
Kuhnia hitchcockii
Kuhnia suaveolens
Liatris scariosa (L. aspera)
Liatris squarrosa compacta
Liatris punctata

Anthemidaceae

Achillea lanulosa
Achillea millefolium
Anthemis cotula
Artemisia campestris caudata
Artemisis dracunculus glauca
Artemisia vulgaris gnaphalodes
  Including minor forms.
Artemisia vulgaris ludoviciana
Artemisia vulgaris mexicana
Chrysanthemum leucanthemum

Senecionidaceae

Senecio plattensis

Carduaceae

Arctium minus
Centaurea americana
  A waif.
Centaurea cyanus
Cirsium altissimum
Cirsium lanceolatum
  Infrequent.
Cirsium ochrocentrum
  Short-spined form.
Cirsium undulatum

Lactucaceae

Agoseris cuspidata
Cichorium intybus
  Two stations. At one place the flowers were sessile, at the other, long peduncled.
Hieracium longipilum
Lactuca canadensis
Lactuca canadensis integrifolia (L. sagittifolia)
Lactuca ludoviciana f. campestris
Lactuca pulchella
Lactuca serriola (L. scariola)
Lygodesmia juncea
Pyrrhopappus grandiflorus
Seriñia oppositifolia
Sonchus asper
Taraxacum laevigatum (T. erythrospermum)
Taraxacum vulgare (T. officinale)
Tragopogon porrifolius
Tragopogon pratensis

Variations in Systemic Infections of *Uromyces caladii*

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The systemic perennial rusts have been remarkably successful in solving many of the problems which threaten their existence, especially the problems of yearly growth, establishment of infection, and sporulation. Since the mycelium hibernates in the dormant parts of the host and begins its growth at the same time as the host plant, it is assured of a large measure of success. Moreover the balance between host and parasite is so delicate and finely adjusted that both achieve what is to all intents and purposes practically normal development. *Uromyces caladii* is a good example of a rust whose haploid mycelium is systemic and perennial on *Arisaema triphyllum* and *A. dracontium*. As the leaves unfold in the spring, pycnia appear on the blades, petioles, leaf sheathes, and even on the spathe and spadix, often before these parts are fully developed; later these will be followed by the aecia. In many instances the leaf is completely invaded by the mycelium and theoretically, since all parts of the dormant corm, including the growing point, are infected, *all* leaves might be expected to be completely infected. This is not always the case, however, and it is very common to find leaves which are but partially infected. This paper presents some of the observations which have been made on these partially infected plants.

In the spring of 1936 a number of infected Arisaema plants were collected and potted for the purpose of conducting certain experiments. Ninety-five plants in all were collected and only those whose leaves were showing abundant infection were chosen. Of these, 48 were completely infected and 47 were partially infected. Again in the spring of 1937 additional plants were gathered and 12 were found to be completely invaded, while 25 were partially infected. Because in this latter case all of the infected plants in a given region were removed, it is quite evident that the partially infected plants are much more numerous than the completely infected plants. Of the many infected leaves that had been gathered at various times and in various localities and which were later pressed, the large majority were of the second type. These leaves displayed such a wide variation that it was decided to study this phase somewhat further.

In order to indicate accurately the limits of variation it became necessary to ascertain the extent of invasion of each individual leaf. The following procedure was therefore employed. The leaf selected for study was carefully traced on paper and the infected area was outlined. By transmitted light the infected areas are at once apparent; the pycnia and aecia show up clearly and usually the area invaded has a darker color which is unmistakable. It is therefore possible to determine very accurately the extent of mycelial invasion. Two methods were employed in determining the actual area of the leaf and of the infected parts; first by using squared graph paper; and secondly by a planimeter. The second method was found to be more rapid and much more accurate than the first, and accordingly all readings were obtained by the use

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of the planimeter.[1] The leaf of Arisaema being trifoliolate, each leaflet was worked out separately. The lower surface of each leaf was drawn and the leaflets were numbered in counter-clockwise fashion beginning at the leaflet on the right. In all about 55 leaves were studied.

One characteristic of practically all infected leaves was the tendency for the infected areas to be confined to the region of the midrib. This is shown most clearly in the leaves which had a low percentage of infection. Leaf No. 19, shown in figure 1, illustrates this very well, especially in leaflet No. 2. In leaflets 1 and 3 a few pycnia were found along the base of the midrib, and the readings for these two leaflets were correspondingly low, being .015% and .025% respectively. Leaflet No. 3 of leaf No. 11 (fig. 1) is also a good example of tissue invasion in the midrib region.

A second characteristic of partially infected leaves is the distortion of the shape as a result of the presence of the fungus. The mycelium interferes with the normal enlargement of the leaf blade and as a result such areas are very much reduced in size. A study of leaflet 2 of leaf No. 19 (fig. 1) reveals the stunting effect of the fungus. This is especially noticeable when this leaflet is compared with two disease-free leaflets. Leaf No. 11 (fig. 1) displays this same effect in all three leaflets. Leaves containing higher percentages of infection show this to an even greater degree. In one leaf, No. 25 (table I) leaflet 1, which was practically disease-free, had a total leaf area of 5,036 sq. mm.; leaflet 2, with 51.6% infection, had an area of 3,372 sq. mm.; leaflet 3 with 58.2% infection had an area of 3,500 sq. mm.; this indicates that the fungus caused a decrease in total area of 1,500-1,700 sq. mm., a considerable loss when expressed in terms of photosynthetic tissue.

A third characteristic is the influence of the lateral veins in limiting the extent of mycelial invasion. This is shown clearly in leaflet 2 of leaf No. 19, and leaflet 1 of leaf No. 11 (fig. 1). Occasionally disease-free islands are found in infected leaves (fig. 1, leaf No. 30), the veins here being an effective boundary and preventing the fungus from invading the enclosed tissues. In a few cases the mycelium appears to force its way across this natural boundary (leaflet 1, leaf No. 19 and leaflet 2, leaf No. 11 of fig. 1). The explanation for these exceptions might be found in the age of the leaf at the time it became infected.

Some of the results have been summarized in table I and the leaves arranged in order of percentage of infection. The leaf showing the least amount of infection had two leaflets which were free from the rust. Most of the lightly infected leaves had one or more free leaflets. In general there was considerable variation in the three leaflets of any one leaf. The maximum difference was found in leaf No. 28, which had 54.5% infection, where the difference between leaflets 2 and 3 was 59.82%. Of 48 leaves four had differences between 50% and 60%; three between 40% and 50%; seven between 30% and 40%; eight between 20% and 30%; twenty-two between 10% and 20%; four less than 10%. Two leaves had leaflets whose differences were as low as 4%. Two leaves of approximately the same percentage of infection may have individual leaflet percentages which closely correspond, as in leaves No. 16 and No. 36 (table I) or which may be greatly dissimilar, as a comparison of leaves No. 12 and No.

1. The writer wishes to acknowledge the assistance of Wayne Martin, a senior biology major, in working out the figures and the percentages.

TABLE I.—Detailed study of a group of partially infected leaves

All leaves were drawn from lower surface and leaflets numbered in the following order: right, center and left

Leaf No.	Percent infected.	Infection in individual leaflets.		
		No. 1.	No. 2.	No. 3.
51	1.9	0.00	5.83	0.00
40	4.2	0.00	11.11	1.54
45	6.9	8.01	8.64	4.10
50	10.6	1.76	30.31	0.00
43	15.4	20.09	26.23	0.00
20	22.2	10.59	17.38	38.54
15	27.4	30.04	35.14	17.21
12	32.1	47.85	17.61	30.83
46	32.2	24.24	32.44	40.00
18	34.7	24.81	40.03	39:39
25	37.7	3.40	51.62	58.29
11	38.3	35.81	61.55	17.45
48	42.2	39.77	58.45	28.66
31	49.1	47.76	37.18	62.41
16	54.2	63.28	45.09	54.47
36	54.3	62.00	45.67	55.43
38	54.5	43.71	89.82	30.00
3	57.8	66.78	72.94	33.71
9	61.8	65.52	51.57	68.52
37	64.9	59.41	67.04	68.47
7	64.9	81.55	67.34	45.82
13	66.1	75.91	63.06	59.53
21	69.7	63.06	65.74	81.13
44	72.8	63.23	81.19	74.22
30	78.3	77.04	70.77	80.15
4	90.3	87.55	92.25	90.93

16, or of leaves No. 37 and No. 7 will show. Even two leaves borne on the same plant, typical of older or more mature specimens, may vary in the amount of infection. While no percentages have been obtained from such cases, several times in the field the plants have been found with one leaf completely infected, while its 'twin' leaf has been only partially infected.

DISCUSSION

It is evident that the amount of infection in any given leaf is determined by the amount of mycelium in the leaf primordium. Abundant mycelium would likely result in a high percentage of infection, while scanty mycelium conceivably would produce such results as are indicated by the figures at the top of table I. All degrees of infection have been found and it therefore might be possible to explain these results on the theory that following initial infection there is a gradual increase in the percentage of infection until, conditions continuing favorable, the host was completely infected. The length of time required for the parasite to achieve this point would perhaps vary with the amount of inoculum and the size of the host plant. Scanty inoculum and a large plant no doubt produce but a small amount of mycelium, while a heavy inoculation on a smaller plant might produce a much higher percentage of infection. Should this theory be true one might expect that once the fungus attained one hundred percent infection each successive year would yield the same percentage. This, however, is pure speculation, as no experimental evi-

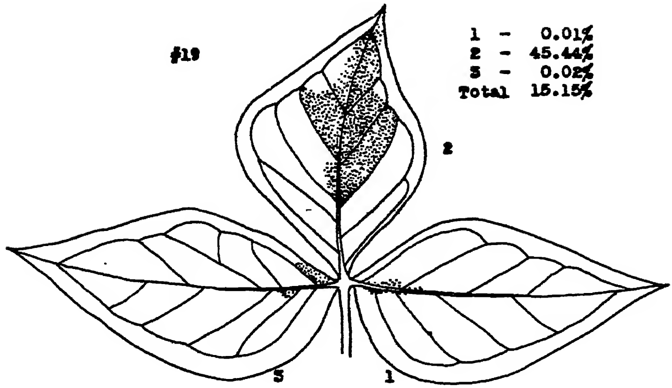
dence along this line is available at the present time. Doubtless there are many other factors which must be considered in this study of the host-parasite relationship.

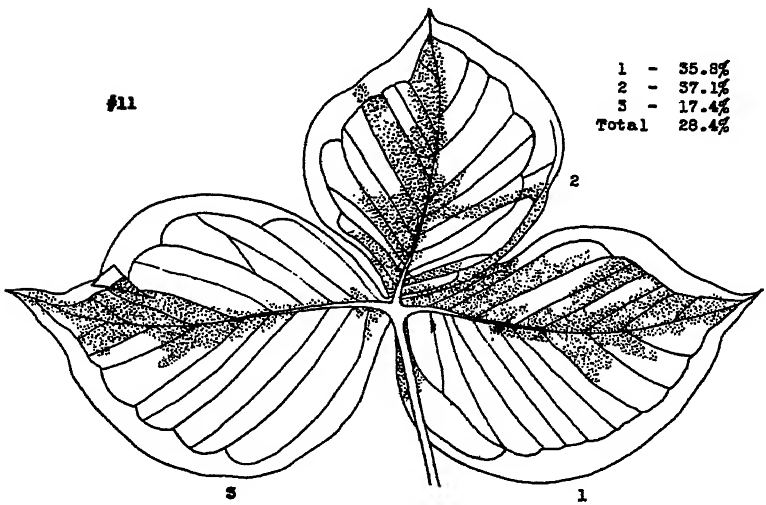
As soon as the leaves begin to unfold the first pycnia appear, indicating that so far as the fungus is concerned there is a very short vegetative period in which the mycelium grows rapidly through the enlarging plant. This is followed by the reproductive phase during which the pycnia and aecia appear, and there is no further invasion of new tissues. This means that the pattern of the partially infected leaf is laid down very early and, is not materially changed subsequently. Most leaves have one or more "free" areas, that is, areas in the leaf which are completely surrounded by mycelium, yet which are completely free. If this tissue is not invaded during the vegetative period of the fungus then it will remain completely free from infection. These areas are usually small and are marked by the boundaries of the lateral veins.

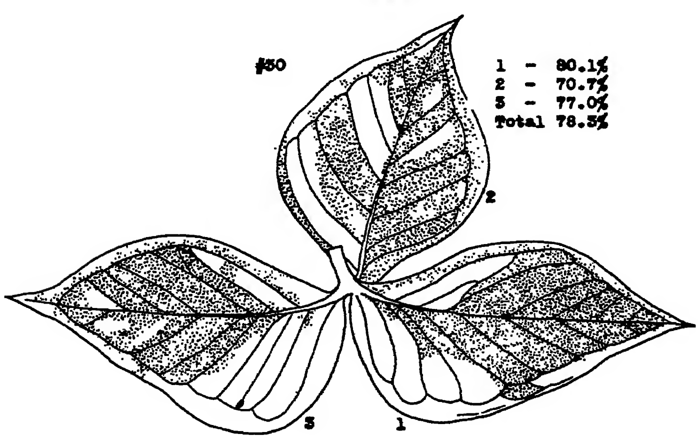
Pedigreed plants grown yearly under the same conditions would be ideal for the study of such types of variations as have been noted above. One unsuccessful attempt has already been made, using infected plants gathered in the spring of 1936 and then growing them in the greenhouse in the summer of 1937. At this time growing conditions were decidedly unfavorable and most of the plants did not survive. This experiment has been temporarily abandoned until greenhouse facilities become available during the period when the plants will grow to the best advantage; this period would be from late January to late spring. It would also be desirable to grow plants which had been experimentally infected. Would these produce pycnia and aecia the first year? Would the leaf be partially or completely infected? Would there be any difference in the age and therefore in the size of the host at the time of infection? Would there be any variation in subsequent years? *Uromyces caladii* appears to be most favorable experimental material with which to work out the answers to such questions.

EXPLANATION OF PLATE

FIGURE 1. Three leaves of *Arisaema triphyllum* infected with *Uromyces caladii.* The area invaded by the mycelium is indicated by stippling. All drawings are of the lower surface of leaflets, and are numbered counter-clockwise. Reduced approximately one-half.


#19
1 - 0.01%
2 - 45.44%
3 - 0.02%
Total 15.15%
2
3
1


#11
1 - 35.8%
2 - 37.1%
3 - 17.4%
Total 28.4%
2
3
1


#50
1 - 80.1%
2 - 70.7%
3 - 77.0%
Total 78.5%
2
3
1

A Preliminary Survey of the Flora of Crawford County State Park, Kansas

BENNINGTON ROSS and HARRY H. HALL, Pittsburg, Kan.

INTRODUCTION

Crawford County State Park is of interest because it contains an area that was mined with a steam shovel by the strip method, between 1917 and 1927. This area, having a very broken topography of mounds and pits, was abandoned as waste land and allowed to revert to natural vegetation. The strip land presents the appearance of a forest, in contrast to the open prairie at the outer edges of the park.

LOCATION

Crawford County State Park is located three miles north of Pittsburg, Kan., on U. S. Highway 69.

PURPOSE OF THE SURVEY

The purpose of this survey was to locate and identify the species of plants in the park, and to compare the plants growing on the disturbed area with those growing on the prairie at the outer edge of the park. This paper is based on the plants found during the growing season of 1938. The set of plants is deposited in the museum at Kansas State Teachers College, Pittsburg, Kan.

This list includes spermatophytes which are not grasses, sedges, rushes or aquatic plants. There were found 66 families, 161 genera and 251 species. Of these, 87 species had not been previously reported from Crawford county. The following plants were not found in the park, but in most cases were quite near, and might have been overlooked: *Monarda punctata occidentalis, Schrankia uncinata, Petalostemum candidum, Petalostemum purpureum, Amorpha canescens, Vernonia crinita, Echinacea angustifolia, Coreopsis tinctoria, Helenium autumnale,* and *Silphium laciniatum.*

GEOLOGY AND SOIL CONDITIONS

In the natural part of the area a dense claypan subsoil extends downward to a layer of black shale or slate rock of varying thickness, which lies immediately above the deposit of coal. The total depth from the surface to the vein of coal varies from 15 to 35 feet. The topsoil is Parsons silt loam. In removing the earth from above the coal and piling it aside the surface soil was promiscuously mixed with sterile subsoil and rock, leaving a very irregular surface which had to undergo a certain amount of leaching and weathering before it was suitable to support plant growth. The dense claypan subsoil being broken, however, made it possible for deep rooting plants to thrive.

Trans. Kansas Acad. Science, Vol. 42, 1939.

TOPOGRAPHY AND CLIMATE

Before the strip mining was begun the surface of the land was nearly level or gently rolling. Two small creeks had flowed across the tract. The topography of the mined area was changed considerably, shifting the courses of the creeks to include several small lakes in the beds of the streams.

Approximately 60 acres of artificial lakes are now distributed throughout the mined portion. The largest of these has an area of 15.8 acres, and five lakes have each an area of six or more acres. Many of the peaks of upheaved earth rise twenty or thirty feet above the lake levels, while other areas are depressed and poorly drained, forming numerous small lakes or ponds during a rainy season. In late summer most of these shallow lakes dry up, forming swamp or marsh areas which can be found throughout the park.

Crawford County State Park offers many distinct habitats. On the prairie may be found well drained areas, and marsh areas. The aquatic habitat offered by the deeper permanent lakes has not yet been studied. The depressed areas of the strip land provide a marsh habitat comparable to the moist areas bordering the streams on the surrounding prairie, while the peaks of upheaved earth provide a xerophytic habitat, on which only the hardier species of plants are able to establish themselves. The more level portions of the strip land are comparable to the surrounding prairie and support a vigorous growth of herbaceous and woody plants.

Along the stream which flows southwest out of the southeast corner of the park, the growth of woody plants is quite dense. The number of species present is not large, the more prominent ones being *Salix fragilis, Quercus palustris, Diospyros virginiana* and *Populus virginiana.* West of the southwest corner of the park the stream which flows out of the park is bordered with woody plants, predominantly willow and cottonwood. Before the mining was begun in 1917, it is quite likely that a strip of woody plants followed the two streams across the section and provided a source for many of the woody plants now found in the park.

This survey shows that the strip land is capable of producing a more extensive and varied plant life than the surrounding prairie. Approximately three species were found on the strip land for each two found on the prairie. The woody plants predominate on the strip land and indicate a tendency to develop into a natural forest. Due to a changed topography, new habitats offer protection to plants unable to survive on the open prairie.

The plants included are listed according to the "Flora of the Prairies and Plains of Central North America" by P. A. Rydberg. The habitat, location within the park, frequency of occurrence and month of flowering are indicated in four columns in the list. The four divisions of the park are indicated on the map accompanying. Specimens planted in the park are designated by (Pl) in the frequency column. The flowering dates are approximate.

LIST

The following abbreviations are used: Hab.= habitat; Pr.= prairie; St.= strip; M.= marsh areas; X.= xerophytic or upheaved strip land; Loc.= location within the park; Fre.= frequency; Pl.= planted; E.= escaped; R.= rare, not well established; O.= occasional; C.= commonly found; A.= abundant.

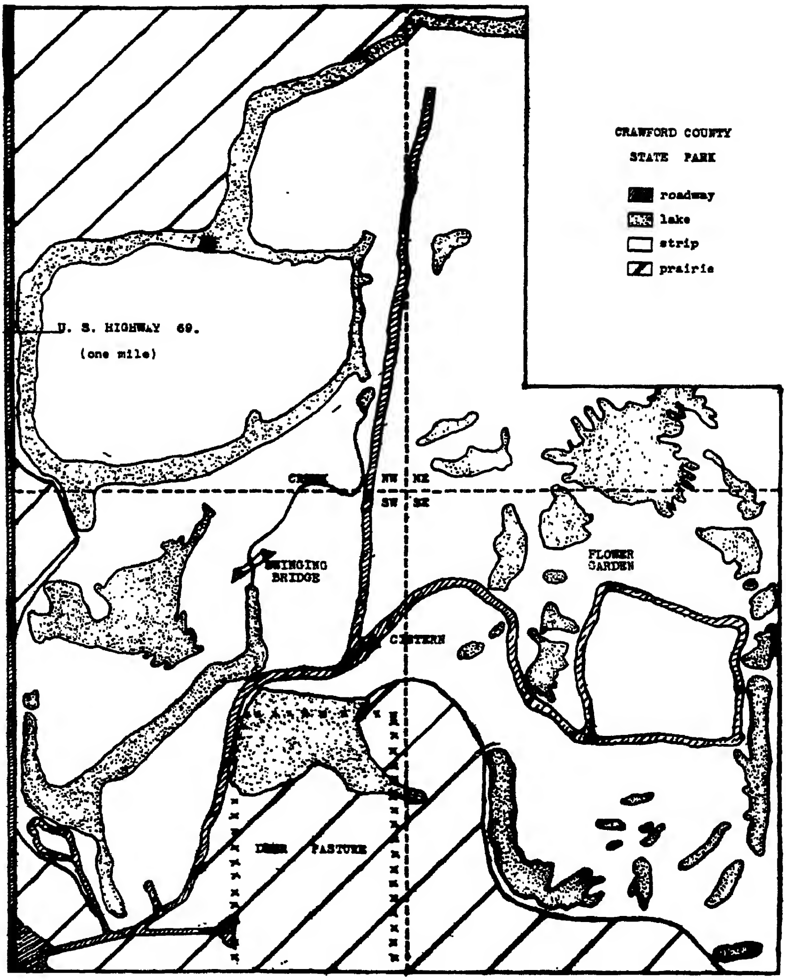
Scientific Name.	Habitat.	Location.	Frequency.	Date.
PINACEAE. Pine Family.				
Pinus nigra	St	T	Pl	....
Pinus sylvestris	St	T	Pl	....
Pinus banksiana	St	T	Pl	....
Taxodium distichum	Pr	SW	Pl	....
JUNIPERACEAE. Juniper Family.				
Juniperus communis	St	T	Pl	May
Juniperus virginiana	St	T	Pl	May
TYPHACEAE. Cat-tail Family.				
Typha latifolia	M	T	A	April
Typha angustifolia	M	SE	R	April
ALISMACEAE. Water-plantain Family.				
Sagittaria latifolia	M	M	R	August
COMMELINACEAE. Spider-wort Family.				
Tradescantia canaliculata	Pr	T	C	Apr.-May
Commelina erecta	Pr-M	T	C	May-Sept.
LILIACEAE. Lily Family.				
Allium canadense	M	T	C	Apr.-Jun.
Nothoscordum bivalve	Pr	T	C	Mar.-May
Erythronium albidum	Pr	T	C	Mar.-April
Asparagus officinalis	St	SW	E	....
Yucca filamentosa	St	SE	Pl	May-July
Smilax hispida	Pr-St	T	C	....
AMARYLLIDACEAE. Amaryllis Family.				
Hypoxis hirsuta	Pr	T	C	April
IRIDACEAE. Iris Family.				
Iris germanica	St	SE	Pl	May
Sisyrinchium campestre	Pr	T	C	May-June
SALICACEAE. Willow Family.				
Populus alba	Pr-St	SE	C	....
Populus alba bolleana	St	SE	Pl	....
Populus virginiana	St-Pr	T	A	Apr.-June
Populus nigra italica	Pr	SW	Pl	....
Salix nigra	St	T	C	Apr.-May
Salix fragilis	St-Pr	T	A	Apr.-May
Salix alba vitellina	St-Pr	SE	C	Apr.-May
Sailx babylonica	St	SE	Pl	....
JUGLANDACEAE. Walnut Family.				
Juglans nigra	St	SW	R	....
Carya pecan	St	T	Pl	....
FAGACEAE. Beech Family.				
Quercus palustris	St-Pr	T	C	....
Quercus borealis maxima	St-Pr	T	R	....
ULMACEAE. Elm Family.				
Ulmus americana	St-Pr	T	C	Mar.-April
Ulmus fulva	St	NE-NW	R	....
Celtis occidentalis	St	T	C	....
MORACEAE. Mulberry Family.				
Morus alba	St	SE	R	....
Morus rubra	St	T	C	April
Maclura pomifera	St-Pr	T	C	April
URTICACEAE. Nettle Family.				
Boehmeria cylindrica	M	NE-SE	C	July-Sept.
Boehmeria drummondiana	M	NE-SE	O	July-Sept.

Scientific Name.	Habitat.	Location.	Frequency.	Date.
Polygonaceae. Buckwheat Family.				
Rumex acetosella	Pr	T	C	Apr.-Aug.
Rumex altissimus	M-Pr	T	C	Apr.-June
Rumex crispus	St-Pr	T	C	June-Aug.
Polygonum neglectum	X	T	O	May-Oct.
Polygonum coccineum	M	NE	R	Aug.-Oct.
Polygonum longistylum	M-Pr	T	C	July-Sept.
Polygonum hydropiperoides	M	T	C	June-Sept.
Polygonum scandens	St	T	C	July-Aug.
Chenopodiaceae. Goosefoot Family.				
Chenopodium boscianum	Pr-X	T	O	July-Sept.
Chenopodium ambrosioides	St	SE	R	Aug.-Oct.
Amaranthaceae. Amaranth Family.				
Amaranthus retroflexus	St-Pr	T	C	June-Oct.
Acnida tamariscina	St	NW	C	July-Sept.
Nyctaginaceae. Four-o'clock Family.				
Mirabilis nyctaginea ovata	St	T	C	May-Aug.
Phytolaccaceae. Pokeweed Family.				
Phytolacca decandra	St-Pr	T	C	July-Sept.
Aizoaceae. Carpetweed Family.				
Mollugo verticillata	St	SE	R	August
Portulacaceae. Purslane Family.				
Claytonia virginica	Pr	SE	R	Mar.-May
Alsinaceae. Chickweed Family.				
Stellaria media	Pr	SE	R	Jan.-Dec.
Caryophyllaceae. Pink Family.				
Silene stellata	St-Pr	SE-SW	C	June-Aug.
Ranunculaceae. Crowfoot Family.				
Ranunculus abortivus	M-Pr	SE	C	May-June
Brassicaceae. Mustard Family.				
Lepidium densiflorum	St-Pr	T	O	April-Oct.
Capsella bursa-pastoris	St-Pr	T	C	Jan.-Dec.
Grossulariaceae. Gooseberry Family.				
Ribes missouriense	St	SW	R	April
Platanaceae. Plane-tree Family.				
Platanus occidentalis	St	SE	R	May
Rosaceae. Rose Family.				
Potentilla simplex	St-Pr	T	C	May-July
Potentilla monspeliensis	St-Pr	T	C	May-Sept.
Fragaria virginiana illinoensis	St	T	C	Apr.-June
Geum canadense	M-Pr	T	C	May-Aug.
Rubus occidentalis	St	T	R	June-July
Rubus ostryifolius	St-Pr	T	O	May-July
Rubus flagellaris	St-Pr	T	O	May-July
Rosa suffulta	St-Pr	T	O	May-July
Crataegus sp	St	T	O	May-June
Prunaceae. Plum Family.				
Prunus lanata	St	T	O	Apr.-May
Prunus virginiana	St-Pr	T	C	May
Prunus persica	St	SE	E	May
Mimosaceae. Mimosa Family.				
Desmanthus illinoensis	St	T	C	May-June
Schrankia uncinata	....	....	....	June-Sept.
Cassiaceae. Senna Family.				
Gleditsia triacanthos	St	T	C	....
Cassia marilandica	....	....	....	Aug.-Sept.
Chamaecrista fasciculata	Pr-St	T	C	June-Sept.

Scientific Name.	Habitat.	Location.	Frequency.	Date.
Fabaceae. Pea Family.				
Baptisia leucantha	Pr	T	C	June-July
Baptisia leucophaea	St	T	C	Apr.-May
Trifolium pratense	Pr-St	T	E	May-Sept.
Trifolium repens	Pr-St	T	C	Apr.-Oct.
Trifolium reflexum	....	....	....	....
Medicago sativa	St	SE	P	May-Sept.
Melilotus alba	St	T	P	May-Sept.
Melilotus officinalis	St	T	P	June-Sept.
Acmispon americanus	Pr	T	A	June-Aug.
Amorpha fruticosa	St	T	A	May-June
Amorpha canescens	....	....	....	June-Aug.
Petalostemum candidum	....	....	....	June-Aug.
Petalostemum purpureum	....	....	....	June-Aug.
Robinia pseudo-acacia	St-Pr	T	C	May-June
Astragalus canadensis	Pr	SE	O	Aug.-Sept.
Meibomia bracteosa	....	....	....	....
Meibomia sessilifolia	Pr-St	T	C	June-Sept.
Meibomia ililnoensis	Pr-St	T	C	June-Sept.
Meibomia canadensis	Pr-St	T	O	July-Sept.
Lespedeza capitata	Pr	T	C	Aug.-Oct.
Lespedeza striata	Pr	T	C	July-Sept.
Apios americana	St	NW	....	August
Strophostyles helvola	St-Pr	T	....	July-Sept.
Strophostyles helvola missouriensis	Pr-St	T	C	Aug.-Sept.
Strophostyles leiosperma	St-Pr	T	C	Aug.-Sept.
Geraniaceae. Geranium Family.				
Geranium carolinianum	St-Pr	T	C	Mar.-Sept.
Oxalidaceae. Wood-sorrell Family.				
Oxalis violacea	St-Pr	T	C	Apr.-Sept.
Oxalis corniculata	St-Pr	T	C	Apr.-Nov.
Simarubaceae. Quassia Family.				
Ailanthus altissima	St	SE	R	....
Polygalaceae. Milk-wort Family.				
Polygala viridescens	Pr	SE	R	June-Sept.
Euphorbiaceae. Spurge Family.				
Croton capitatus	Pr-St	T	C	....
Acalypha gracilens	St-Pr	T	C	June-Sept.
Chamaesyce hyssopifolia	St-Pr	T	C	Aug.-Sept.
Chamaesyce stictospora	St	SE	C	Mar.-Oct.
Celastraceae. Staff-tree Family.				
Celastrus scandens	St	T	R	June-Aug.
Anacardiaceae. Sumac Family.				
Rhus copallina	Z-St	T	A	June-Aug.
Rhus glabra	Z-St	T	A	June-Aug.
Toxicodendron radicans	St-Pr	T	R	....
Aceraceae. Maple Family.				
Acer saccharinum	St-Pr	T	C	....
Acer negundo	St	SE	R	....
Vitaceae. Grape Family.				
Vitis cinerea	St	SE-NE	C	Apr.-June
Ampelopsis cordata	St	T	C	May-June
Parthenocissus quinquefolia	St	T	C	....
Hypericaceae. St. John's-wort Family.				
Hypericum punctatum	Pr	T	C	July-Sept.
Hypericum mutilum	Pr	T	C	July-Sept.
Violaceae. Violet Family.				
Viola sororia	Pr-St	T	C	April May
Viola rafinesquii	Pr	T	C	April May
Onagraceae. Evening Primrose Family.				
Jussiaea diffusa	St-M	T	C	June-Aug.
Ludwigia alternifolia	M-Pr	T	C	July-Aug.
Oenothera strigosa	St-Pr	T	C	June-Oct.
Gaura biennis pitcheri	Pr-St	T	C	July-Sept.

Scientific Name.	Habitat.	Location.	Frequency.	Date.
Ammiaceae. Carrot Family.				
Eryngium yuccifolium	Pr	T	C	July-Aug.
Ptilimnium nuttallii	Pr	T	C	July-Aug.
Sanicula canadensis	Pr	T	C	July-Aug.
Cicuta maculata	M	T	C	June-Sept.
Cornaceae. Dogwood Family.				
Cornus amomum	S	T	C	May
Ebenaceae. Ebony Family.				
Diospyros virginiana	X-St	T	C	June
Oleaceae. Olive Family.				
Fraxinus americana	St	T	C	April-May
Fraxinus pennsylvanica lanceolata	St	T	R	April
Apocynaceae. Dogbane Family.				
Apocynum sibiricum	X	T	C	June-Aug.
Asclepiadaceae. Milkweed Family.				
Acerates viridiflora	Pr-St	T	C	June-Aug.
Acerates angustifolia	Pr-St	T	C	June-Aug.
Asclepias tuberosa	Pr	T	C	June-Sept.
Asclepias syriaca kansana	St	SE	R	June-Sept.
Asclepias incarnata	M-St	T	C	June-Aug.
Asclepias verticillata	Pr	T	O	June-Sept.
Asclepidora viridis	Pr	T	O	June-Sept.
Convolvulaceae. Morning-glory Family.				
Ipomoea hederacea	St	NW	R	June-Sept.
Verbenaceae. Vervain Family.				
Verbena urticifolia	St	T	C	June-Sept.
Verbena simplex	St	T	O	June-Sept.
Verbena urticifolia X simplex	St-Pr	T	O	May-Aug.
Verbena bracteosa	St-Pr	SE	R	May-Aug.
Verbena canadensis	St-Pr	T	C	May-July
Lippia lanceolata	M-St	SE-SW	C	June-Oct.
Lamiaceae. Mint Family.				
Teucrium canadense	St-Pr	T	O	August
Dracocephalum denticulatum	Pr	T	C	June-Aug.
Monarda mollis	Pr-St	T	C	June-Aug.
Monarda punctata occidentalis	Pr	T	C	May-July
Pycnanthemum pilosum	Pr	T	C	July-Sept.
Lycopus virginicus	M-St	T	C	July-Sept.
Solanaceae. Potato Family.				
Physalis pubescens	St	SE	R	July-Sept.
Physalis macrophysa	St-M	SE-SW	C	May-July
Physalis heterophylla	St	T	C	May-Sept.
Solanum nigrum	St	T	C	May-Oct.
Solanum carolinense	St-Pr	T	C	June-Sept.
Scrophulariaceae. Figwort Family.				
Scrophularia marilandica	St	SW	R	July-Sept.
Penstemon digitalis	Pr-St	T	C	May-June
Veronica arvensis	Pr	T	O	August
Gerardia skinneriana	Pr	T	C	Aug.-Oct.
Bignoniaceae. Trumpet-creeper Family.				
Campsis radicans	St	T	R	....
Catalpa speciosa	St	T	C	May-June
Acanthaceae. Acanthus Family.				
Ruellia caroliniensis	St	T	C	June-Sept.
Ruellia strepens	St	SW	R	Aug.-Oct.
Plantaginaceae. Plantain Family.				
Plantago rugelii	St	T	C	June-Sept.
Plantago lanceolata	St	SE-SW	C	April-Oct.
Plantago aristata	St	SE	O	May-Oct.
Plantago rhodosperma	St	SE	O	Mar.-June
Rubiaceae. Madder Family.				
Houstonia minima	St-Pr	T	C	Mar.-April
Diodia teres	St-Pr	T	C	July-Sept.
Galium aparine	St-Pr	T	C	May-Sept.
Galium verum	St	SE	R	Mar.-Sept.

Scientific Name.	Habitat.	Location.	Frequency.	Date.
CAPRIFOLIACEAE. Honeysuckle Family.				
Sambucus canadensis	St-M	T	C	June-July
Symphoricarpos orbiculatus	St-Pr	T	C	July
Lobelia cardinalis	M-St	T	R	Aug.Oct.
VALERIANACEAE. Valerian Family.				
Valerianella radiata	St	SE-SW	O	July Aug.
AMBROSIACEAE. Ragweed Family.				
Iva ciliata	St-Pr	T	C	Aug.-Sept.
Ambrosia bidentata	Pr-St	T	C	Aug.-Sept.
Ambrosia trifida	Pr-St	T	C	Aug.-Sept.
Ambrosia media	St-Pr	T	A	July-Oct.
Xanthium pennsylvanicum	St M	T	R	Aug.-Sept.
CARDUACEAE. Thistle Family.				
Vernonia crinita	St	....	....	July-Oct.
Vernonia missourica	St-Pr	T	C	July-Sept.
Eupatorium perfoliatum	St-Pr	T	C	July-Sept.
Eupatorium altissimum	Z-St	T	C	July-Sept.
Eupatorium serotinum	Z-St	T	A	Sept.-Nov.
Eupatorium rugosum	M-Pr	T	C	Aug.-Oct.
Kuhnia suaveolens	St-Pr	T	A	Aug.-Oct.
Liatris aspera	Pr	NW-NE	R	Aug.-Sept.
Liatris pychnostachya	Pr	SW	R	July-Aug.
Grindelia lanceolata	St	T	R	July-Aug.
Solidago glaberrima	Pr	T	C	Aug.-Oct.
Solidago inornata	St-Pr	T	A	July-Oct.
Solidago glaberrima morituro	Z-St	T	A	July-Oct.
Solidago serotina	Z-St	T	A	July-Sept.
Solidago canadensis gilvocanescens	Z	T	A	July-Sept.
Solidago speciosa angustata	Pr	T	C	Aug.-Oct.
Solidago rigida	Pr	T	C	Aug.-Sept.
Amphiachyris dracunculoides	Pr	T	C	Aug.-Oct.
Enthamia gymnospermoides	Pr	T	C	Aug.-Oct.
Boltonia latisquama	Pr	T	C	Aug.-Oct.
Aster paludosus	Pr	NE	R	Aug.-Oct.
Aster ericoides	Pr	NE	R	Aug.-Oct.
Aster ericoides stricticaulis	Pr	T	O	Aug.-Sept.
Aster paniculatus	Pr	T	C	Aug.-Sept.
Erigeron ramosus	Pr	T	C	June-Sept.
Erigeron canadensis	Pr-St	T	C	Aug.-Oct.
Gnaphalium obtusifolium	Pr-St	T	C	Aug.-Oct.
Gnaphalium purpureum	Pr-M	T	C	June-July
Silphium laciniatum	....	....	....	July-Sept.
Rudbeckia amplexicaulis	St	SE	R	July-Sept.
Rudbeckia laciniata	Pr	T	R	Aug.-Sept.
Rudbeckia hirta	Pr-St	T	C	July-Aug.
Echinacea angustifolia	....	....	....	June-Aug.
Ratibida pinnata	St	SE	R	July-Aug.
Helianthus annuus	Pr	T	C	July-Sept.
Helianthus rigidus	Pr	NE	C	Aug.-Sept.
Helianthus mollis	Pr	T	C	Aug.-Sept.
Helianthus petiolaris	Pr-St	T	C	June-Sept.
Helianthus tuberosus	Pr-St	T	C	Sept.-Oct.
Helianthus grosseserratus	Pr	T	C	Aug.-Sept.
Helianthus hirsutus	Pr	T	C	Sept.-Oct.
Actinomeris alternifolia	St	SE-NE	C	Aug.-Sept.
Verbesina virginica	St	SE-NE	C	Aug.-Sept.
Coreopsis tinctoria	....	....	....	June-Aug.
Bidens involucrata	Pr-St	T	A	July-Sept.
Helenium tenuifolium	Pr	T	C	July-Sept.
Helenium autumnale	....	....	....	Aug.-Sept.
Achillea millefolium	Pr	T	C	June-Sept.
Anthemis cotula	Pr	SW	R	June-Aug.
Cacalia tuberosa	Pr	T	C	June-Aug.
Erechitites hieracifolia	Pr	SW	O	Aug.-Sept.
Cirsium altissimum	St	T	C	Aug.-Sept.
Taraxacum officinale	St-Pr	T	O	Mar.-June
Pyrrhopappus carolinianus	Pr	SE	R	Aptil-June
Prenanthes aspera	Pr	T	A	Aug.-Sept.
Hieracium longipilum	Pr	SE-SW	O	Aug.-Sept.
Lactuca scariola	St-Pr	T	C	Aug.-Sept.
Lactuca sagittifolia	St	T	C	Sept.-Oct.
Lactuca floridana	St	T	C	Sept.-Oct.
Sonchus asper	St	SW	O	Sept.-Oct.



Map of the park area, showing location of various features.

The Disappearance of a Society of *Camassia esculenta* Following the Burning Over of its Prairie-meadow Habitat

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A prairie meadow in Douglas county, Kansas, has for many years in late April and early May delighted us with the beauty and opulence of bloom of its dense and widespread society of *Camassia esculenta,* often not inaptly called wild hyacinth. Figure 1 is a photograph of the south side of this meadow taken on May 9, 1937. When, however, the time for their blooming came again, in the spring of 1938, no Camassias were in evidence, excepting where they had invaded open spaces between the shrubs and herbaceous perennials in the southeast corner of the meadow. Wondering what evil influences had wrought this havoc, we noticed that the surface of the meadowland was blackened by fire, while nothing of this appeared in the southeast corner. Evidently burning the grass had caused the disappearance of the Camassias; but how? Asking the man who had charge of the meadow what he knew about it, he told us it was his custom to mow the meadow twice each summer, but he never noticed the flowers there. The meadow had been burned about six years ago but not again until about the first of March of the current spring, when it was fired by cause unknown to him. However, the conflagration could not have been much, because hardly more than stubble remained to be burned. That was all he could say about it. Our question now was, How had burning the stubble before growth had started eliminated the Camassias? Could the heat of the fire have destroyed the bulbs? We do not have to guess the answer, because we have the results of experiments by R. L. Hensel (*3*), Kansas Agricultural Experiment Station, on the effects of such burning. Hensel laid out quadrats in a pasture near Manhattan and in them set self-recording thermometers at a depth of one inch and three inches, respectively, and burned the vegetation in some quadrats while leaving it unburned in others, with the result that the thermometers in the burned quadrats, even at the shallow depth of one inch, did not show appreciably higher temperatures than those in the unburned quadrats. This answers our question. Reference to figure 2 shows that the bulb of the Camassia was living in the third inch beneath the surface, where heat from the burning stubble would not sensibly reach it. Now the question arises whether after-effects of the burning might have existed. Here also, Hensel's experiments provide an answer. He found after-effects as he continued his observations from the time of burning before growth started in the spring until June 10, over a period of four years. He noted that the mean maximum temperatures of the soil at a depth of one inch averaged 12° higher in the burned quadrats than in the unburned, while at a depth of three inches the average was 4° higher in the burned quadrats. These increases in temperature caused a much earlier start in growth in the grasses and sedges. While Hensel did not investigate possible chemical conditions of the soil due to burning, he did discover a drift in the

Trans. Kansas Acad. Science, Vol. 42, 1939.

plant population after burning, such as a tendency to the replacement of *Andropogon furcatus* and *Poa pratensis* by *Andropogon scoparius,* and a decrease in weeds. However, Thomas Eden (*2*), in England, has reported on the chemical phase of the situation. He observed that after burning on Harpenden Common there was an increase in frequency of *Rumex acetosella,* while species of Agrostis were reduced in frequency; but after a few years the original relative frequencies prevailed. Investigating conditions in the soil, Eden found that incomplete combustion of vegetation had given rise to humic acid and the increased soil acidity was good for Rumex but bad for Agrostis. As time went on the humic acid was reduced by percolation and oxidation and the old relative frequency of species came back. We learn from the investigations of Hensel and Eden that while the after-effects of burning are important and progressive, they are not the direct cause of immediate disappearance of an established species. Yet, clearly enough, the burning of the meadow did cause the disappearance of the Camassia society and possibly in the way we will now suggest. Relying on Hensel's discovery that, due to the greater absorption of solar radiation by the blackened covering of the soil, an earlier start in growth resulted, let us suppose that in the spring of 1938 the Camassias started growing earlier than they would have done, the leaves ahead of the flowers by about two weeks, as is the custom with Camassia. Now, the earliest record we have of Camassias blooming in this locality is April 20th. Suppose that in the spring of 1938 the leaves were up in the second week in April. In that week there was freezing weather on the 8th, 9th, and 10th, destroying the unfolding buds and leaves of lilacs, and capable, it would seem, of doing no less to Camassias. If this happened the bulbs would still be living, with their stored food not much depleted.

Bailey's Cyclopedia of Horticulture (*1*) states that Camassia bulbs produce no offsets unless wounded. If, now, the destruction of leaves and the suppression of flower formation reacts on the bulbs as a wound, offsets might result. If this happened, the society may again be dominant in the vernal aspect of the meadow in shorter time than would be required to produce blooming bulbs from seeds, which is reported to be three to four years.

After this paper was presented to the Academy we found, on April 21, leaves of Camassia of varying sizes in the meadow, corresponding to bulbs of different stages of maturity; and now, on May 9, there is very rarely indeed a scape of meager flowers here and there in the meadow, while in the southeast corner of the meadow, where burning did not take place, there is again a small society as of last year.

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PLATE I

FIG. 1. Society of *Camassia esculenta.* Spring of 1937.

FIG. 2. Entire Camassia plant, showing bulb in the third inch of soil. Each square represents 1 square inch.

FIG. 3. Enlarged portion of inflorescence.

PLATE I

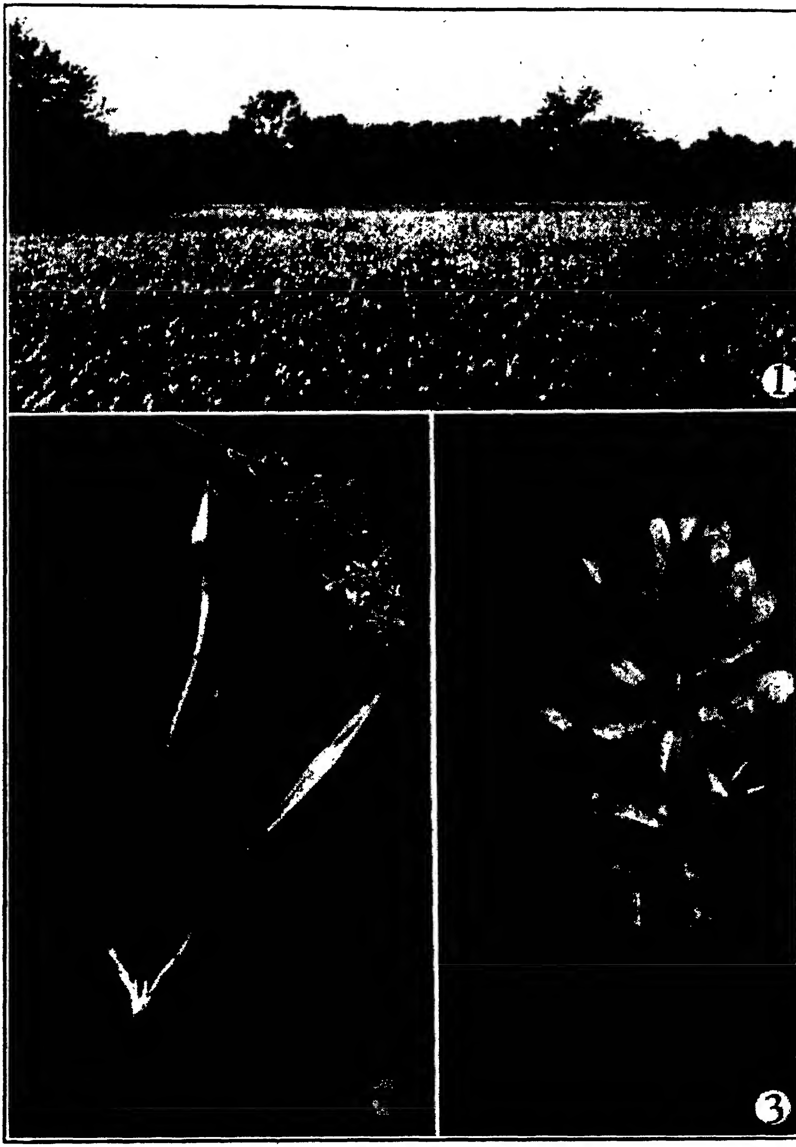

PLATE II

FIG. 4. Croton covering bank facing south on east-west highway.
FIG. 5. Entire croton plant. The squares represent square inches.

PLATE II

Croton monanthogynus and *Lespedeza striata* as Bank Covers

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Our system of graded highways presents hundreds of miles of raw banks for colonization by whatever plants are in position and have the ability to possess them. The soil of these banks is chiefly subsoil of relatively low fertility, and its water content is low due to maximum runoff down their steep slopes and exposure to evaporation from top to bottom.

For colonizing these unpromising areas vegetation from the adjoining land can furnish seeds; and many perennial species, by horizontally advancing rhizomes, reach the surface of the banks and form new crowns there. For example, *Rhus glabra, Amorpha canescens, Monarda mollis, Salvia pitcheri, Pycnanthemum virginianum, Rosa suffulta,* some species of *Helianthus, Solidago* and *Aster*. Annuals suffer the disadvantage of having to begin all over again each year, and, especially when in a difficult exposure to sun and wind, must be tough and efficient. Such a one is *Croton monanthogynus*. Give it but a foothold and it stands fast, as we see in figure 4, where, on a bank facing south beside an east-west highway running through high prairie, outcropping rocks arrest enough soil to afford rootage. What habitat could be hotter and drier? Yet, now at the end of summer, these crotons show every sign of well-being and thrift. This photograph shows each plant closely branched and crowned with foliage. A nearer view of a single plant appearing in figure 5, reveals the dichotomously-branching main branches arising verticillately, and a short taproot giving off widely spreading, strong laterals in the second, third and fourth inches of soil. Examining the crown with a magnifier we find all its parts fuzzy with a covering of overlapping stellate trichomes, serving in effect as a microscopic straw mulch, comparable to straw in that it absorbs little from the substratum, and by stiffly maintaining its interspaces provides aeration while reducing the drying-out effect of the wind. Whether the trichomes are effective in absorbing water from rain and dew we have not yet determined, but that they do further serve as shields against the fierce bombardment of solar energy to which the plants are exposed is evident in the sheen which they give to the whole crown.

A survey of figure 4 shows that out of all the great variety of seeds falling on this bank there is none able to produce a successful contender against croton in this environment; but on the opposite side of the highway, a short distance away, where the bank faces north, croton is outdone, even to its elimination, by a variety of annuals and perennials, as we see in figure 3. Here appear familiar lineaments of *Artemisia ludoviciana, Gaura biennis, Helianthus annuus, Andropogon furcatus* fringing the top of the bank, and over one area, near the base where the slope is less steep, a dense society of *Lespedeza striata.* This species from the Orient was first found wild in America, in Georgia, in 1846, and is now naturalized as far north as the Ohio river and westward into Illinois, Missouri and Kansas. It is much cultivated in the South for pasturage,

Trans. Kansas Acad. Science, Vol. 42, 1939.

hay and green manure, thriving in most any soil and even under poor conditions of cultivation, and is now successfully used in Kansas for the same purposes under the name Korean Lespedeza. It is an annual, as figure 7 would show, ascending about a foot, branching as well as foliaceous from close to the base. Here we see also a slender taproot, with many fine laterals in the first three inches of soil, bearing the tubercles that give it an advantage in a nitrogen-poor medium, such as its present subsoil habitat. How dense the massed foliage of the society is and how shade tolerant it is appears in the close-up surface view of figure 8, where the foliage is seen to make a complete coverage. All the characteristics of the species appearing here demonstrate how well it is qualified for a bank cover where the slope is not precipitate; and it would seem that while this species may not cross the highway and compete with croton on a steep south slope, neither could croton win against lespedeza where the environment provides more moisture and less insolation. Although this lespedeza is an annual it has the character of permanence by successfully reseeding itself from year to year.

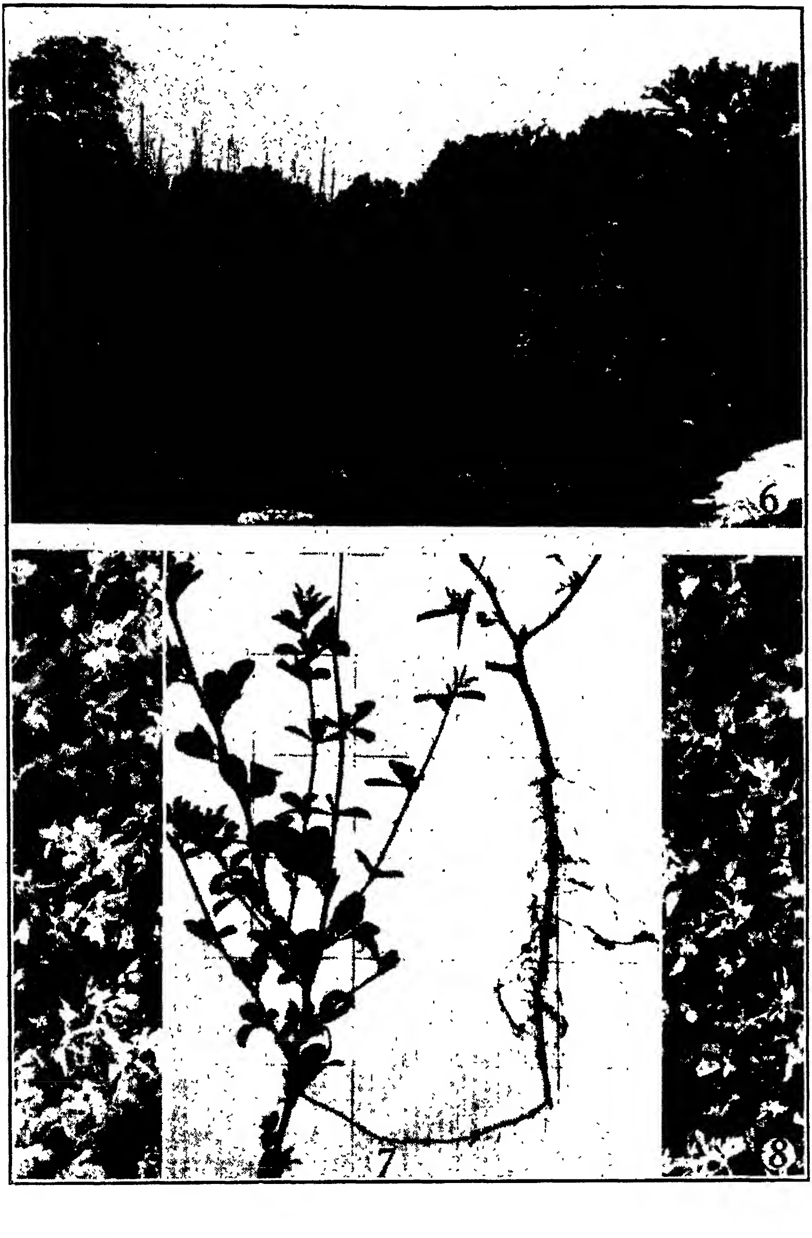
PLATE III

FIG. 6. *Lespedeza striata* occupying lower left quarter on bank facing north of east-west highway.

FIG. 7. Lespedeza, root and top. Tubercles on roots. The squares represent square inches.

FIG. 8. On both sides of Fig. 7. Detail of Lespedeza. Near view, looking down. Complete coverage is shown.

PLATE III



The Seed Plants of Sedgwick County, Kansas [1]

SISTER M. AQUINAS STIEFERMAN, A. PP. S. Sacred Heart Junior College, Wichita, Kan.

The purpose of this survey is to obtain a record of the native angiospermous flora of Sedgwick county, as no such work, to date, has been done on this county. In the list are included some introduced species which, however, are so established as to appear native. Collecting specimens was begun July 20, 1932, and continued throughout the seasons of 1933 and spring of 1934. In an effort to reach all parts of the county, 120 trips by auto were made in 45 weeks. A total of approximately 5,560 miles, or an average of 46 miles per trip, was covered. No attempt was made to keep a record of the number or mileage of the hiking trips.

The second edition of Britton and Brown's "Illustrated Flora of the Northern States and Canada" was largely followed in classifying and arranging the list of plants.

DESCRIPTION OF SEDGWICK COUNTY

Sedgwick county, named in honor of John Sedgwick, major-general in the United States Army, was organized in 1870. It is located in the southeast central portion (longitude 97° W.; latitude 37° 41′ N.) of the state and comprises 644,869 acres, or 1,008 square miles. At the date of its organization it was estimated to consist of 99 percent prairie land and 1 percent timber land.

The soil belongs principally to the Cretaceous (dark clayey shale), and the Permian (red-bed, shale and limestone) soil-provinces. The shale has yielded a black and red loam. This red loam is found especially in the southern part of the county. In the bottomlands the loam is intermingled with sand. Along the Arkansas river there is also considerable rich alluvial soil. The area of the county is about 50 percent upland and 50 percent bottomland, the general surface being only slightly undulating.

The soil is easily pulverized and is well suited for farming. It is very fertile, productive, and easy to till. The western portion of the county is the more fertile and produces the best crops, although some of the most fertile farms of the entire state are located north of Wichita along the Little Arkansas river in the rich alluvial soil region. Sedgwick county has a yearly average of 195 days without killing frost, and as a rule neither extremely hot nor extremely cold weather exists for more than a few days at a time. The mean precipitation for the last fifty years is 29.59 inches. The highest, 41.94 inches, fell in 1922, and the lowest 15.58 inches, fell in 1936. The average precipitation for the period during which the flora collection was made was 23.22 inches.

The principal streams of the county are the Arkansas, Little Arkansas and the Ninnescah. Other smaller streams are the Cowskin, Clearwater, Wildcat, Chisholm, and Gypsum. There are a number of ponds and small lakes. The floating or creeping primrose (*Jussiaea diffusa*), an evening primrose, was found in ponds both in the eastern and the western parts of the county.

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1. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the University of Wichita.

The Great Arkansas river flows almost diagonally across the county, entering at the northwest corner and leaving just six miles west of the southeast corner. It is a wide, shallow stream and its waters soak into the sandy soil and provide subirrigation for probably the width of the valley. It is therefore of immense benefit, especially in extremely dry seasons.

The Little Arkansas has its source in Rice county, enters Sedgwick county at the center of the north line, runs almost due south, and empties into the Great Arkansas in central Riverside Park in Wichita. The Little Arkansas marks the western limit of the oak in this part of Kansas. Its banks are heavily timbered with majestic oak, especially in bends near its mouth. The magnificent stretch of woodland, the broad expanse of water, combined with the art of the landscape gardener has made the junction of these two historic streams in Riverside Park one of the most attractive spots in Kansas.

The north branch of the Ninnescah enters this county in the northwest corner of Grand River township, flows southeast and joins the south branch of the Ninnescah in the southeastern part of Morton township, thence continuing its southeasterly course, and leaves Sedgwick county at the corner of the Ninnescah township. The waters of the Ninnescah are especially pure and clear and in their meanderings they have formed a large tract of rich valley land.

In many places these streams are heavily wooded with cottonwood, elm, hackberry, locust, oak, walnut and, occasionally, hickory. Wild grape vines, climbing bittersweet, smilax, moonseed vine, coralberry, and other shrubs form a dense undergrowth. The avens (Geums) and ticktrefoil (*Desmodium*) are also abundant.

There are many kinds of trees in Sedgwick county, especially in the park systems of Wichita, but only those which are considered native have been included in this list. Sedgwick county is the westernmost station for the big shagbark hickory (*Carya laciniosa*) according to the record from the State Herbarium at Manhattan, Kansas.

The early settlers of the county felt the need of trees for shade, windbreaks, posts and fuel. First, for rapid growth they planted the old-time, reliable cottonwood; then later the boxelder, the elm, catalpa, maple, the locust in its several varieties, and other species. Miles of osage orange for hedges were planted instead of building fences. Many of these hedges are now being destroyed as more and more improved highways are being made.

Sedgwick county has a network of railroads and highways. There are 260 miles of main track and 134.55 miles of improved state highways, besides the county and township roads. But these railroads, and especially the highways, have brought about the extinction of many species in native flora. It is principally along the little by-ways, or off roads, the streams and branch railroad tracks that the native flora is found.

The county with its prosperous city of Wichita as a market place for the farm products, and with its network of railroads and highways, is an agricultural area. There are 3,865 farms in the county. Formerly wheat was the predominating crop raised, but now diversified farming is carried on. Corn, kaffir corn, oats and alfalfa are the principal crops east of the Arkansas river upon the uplands east of Wichita. Some truck farming and fruit raising

prosper, especially in the vicinity of Wichita. Potatoes, sweet potatoes, cantaloupes, tomatoes, and the other more common garden vegetables are extensively cultivated in gardens. There are orchards of apple, peach, cherry and plum; grapes and berries, also, are produced. The farms are well fenced and well cultivated. Only about 15 percent of the land remains in native pasture and this land is heavily stocked for grazing.

For the old settler the entire landscape of Sedgwick county has been changed. Where once were miles of boundless, monotonous prairie stretching away to the horizon, where herds of sleek buffalo grazed in contentment, now there are herds of cattle, cultivated fields, shady groves and beautiful farm homes which present a pleasing picture to the eye. Teeming activity takes the place of prairie peace. Yet the great changes brought about by the settlement (farming, oil drilling, cattle raising and manufacturing) of the prairie have, no doubt, destroyed many species of the original native flora.

The writer wishes to express a debt of gratitude to Dr. C. O. McDonald, Municipal University of Wichita, under whose supervision this survey was made and with whose untiring help and encouragement it was possible to complete it. Sincere appreciation and gratitude are extended to Dr. F. C. Gates, Kansas State College, Manhattan, for his personal interest and help, particularly in the verifying of the identifications. Acknowledgment is also given to Dr. W. H. Horr, University of Kansas, Lawrence, for his assistance in verifying a part of the collection.

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SEED PLANTS OF SEDGWICK COUNTY, KANSAS

TYPHACEAE—Cattail Family

Typha latifolia	Broad-leaved cattail

ALISMACEAE—Water Plantain Family

Sagittaria brevirostra	Short-beaked arrow leaf

POACEAE (GRAMINEAE)—Grass Family

Tripsacum dactyloides	Gama, sesame, bull grass
Andropogon saccharoides	Torrey beard grass
Andropogon furcatus	Forked beard grass, big bluestem
Sorghastrum nutans	Indian grass
Digitaria sanguinalis	Large crab grass, finger grass
Leptoloma cognatum	Diffuse crab grass
Eriochloa contracta	Early spring grass
Paspalum stramineum	Straw-colored Paspalum
Echinochloa crusgalli	Barnyard grass
Echinochloa crusgalli mitis	Barnyard grass
Panicum capillare	Witch grass
Panicum virgatum	Switch grass
Panicum dichotomiflorum	Spreading witch grass
Panicum scribnerianum	Scribner panic grass
Panicum wilcoxianum	Wilcox panic grass
Setaria lutescens	Yellow bristle grass, yellow foxtail, pigeon grass
Setaria italicum	Italian millet, Hungarian grass
Setaria viridis	Green bristle grass, green foxtail grass
Cenchrus pauciflorus	Sandbur
Stipa spartea	Porcupine grass
Aristida oligantha	Few-flowered Aristida prairie triple-awn
Muhlenbergia mexicana	Satin grass, muhly
Alopecurus carolinianus	Foxtail
Sporobolus argutus	Pointed dropseed grass
Sporobolus texanus	Texas dropseed
Sporobolus airoides	Hair grass dropseed
Avena sativa	Oats
Cynodon dactylon	Bermuda grass
Spartina pectinata	Tall marsh grass, slough grass
Chloris verticillata	Windmill grass
Bouteloua gracilis	Grama grass, mesquite grass
Bouteloua curtipendula	Side oats grama, tall grama
Eleusine indica	Wire grass, crab grass
Buchloe dactyloides	Buffalo grass
Phragmites communis	Common reed grass
Triodea flava	Tall redtop
Eragrostis pectinacea	Pursh love grass
Eragrostis cilianensis	Love grass

Eragrostis spectabilis	Purple love grass
Eragrostis secundiflora	Clustered love grass
Eragrostis trichodes	Hair-like love grass
Sphenopholis obtusata	Early bunch grass
Koeleria cristata	June grass
Uniola latifolia	Broad leaved spike grass
Distichlis stricta	Marsh spike grass, salt grass
Poa pratensis	Kentucky bluegrass, June grass
Poa arachnifera	Texas bluegrass
Festuca octoflora	Slender fescue grass
Bromus tectorum	Downy brome grass
Bromus inermis	Hungarian or awnless brome grass
Bromus catharticus	Brome grass
Bromus japonicus	Brome grass
Lolium perenne	Rye grass
Agropyron smithii	Western wheat grass
Agrostis hyemalis	Fool hay, silk grass
Hordeum pusillum	Little barley
Hordeum jubatum	Squirreltail grass
Elymus canadensis	Nodding wild rye
Elymus canadensis robustus	Canada Lyme grass, wild rye
Elymus virginicus	Terrel grass
Elymus virginicus glabriflorus	Smooth southern wild rye

CYPERACEAE—Sedge Family

Cyperus inflexus	Awned cyperus
Cyperus houghtoni	Houghton cyperus
Cyperus acuminatus	Short-pointed cyperus
Cyperus hallii	Hall cyperus
Cyperus esculentus	Yellow nut grass
Cyperus speciosus	Michaux cyperus
Cyperus strigosus	Straw-colored cyperus
Cyperus filiculmis	Slender cyperus
Eleocharis obtusa	Blunt spike rush
Eleocharis macrostachya	Creeping spike rush
Scirpus americanus	Three-square
Scirpus validus	American great bulrush, matrush
Scirpus pallidus	Pale bulrush
Carex sparganioides	Burreed sedge
Carex gravida	Heavy sedge
Carex vulpinoidea	Fox sedge
Carex bicknellii	Bicknell sedge
Carex blanda	Woodland sedge
Carex davisii	Davis sedge
Carex artitecta	Art craftsman's sedge
Carex brevior	Short sedge
Carex lanuginosa	Wooly sedge
Carex meadii	Mead sedge
Carex molesta	Troublesome sedge

COMMELINACEAE—Spiderwort Family

Commelina crispa	Curly leaved dayflower
Commelina virginica	Virginia dayflower
Tradescantia bracteata	Long-bracted spiderwort
Tradescantia canaliculata	Grooved tradescantia or spiderwort
Tradescantia occidentalis	Western spiderwort

JUNCAEAE—Rush Family

Juncus torreyi	Torrey rush

LILIACEAE—Lily Family

Zygadenus nuttallii	Nuttall death camas
Allium perdulce	Wild onion
Allium nuttallii	Nuttall wild onion
Allium mutabile	Wild onion
Allium stellatum	Prairie wild onion
Nothoscordum bivalve	Yellow false garlic
Yucca glauca	Soapweed
Androstephium coeruleum	Androstephium
Smilax hispida	Hispid greenbrier
Smilax bona-nox	Bristly greenbrier

IRIDACEAE—Iris Family

Belamcanda chinensis	Blackberry lily
Sisyrinchium campestre	Prairie blue-eyed grass

JUGLANDACEAE—Walnut Family

Juglans nigra	Black walnut
Carya laciniosa	Big shagbark, kingnut (Westernmost station)

SALICACEAE—Willow Family

Populus sargentii	Western cottonwood
Salix exigua luteosericea	Slender willow
Salix interior	Sandbar willow, river-bank willow

FAGACEAE—Beech Family

Quercus borealis maxima.......	Red oak
Quercus macrocarpa	Mossy-cup, blue or bur oak

ULMACEAE—Elm Family

Ulmus thomasi (U. racemosa)...	Cork or rock elm
Ulmus americana	American or white elm
Celtis occidentalis	Hackberry

MORACEAE—Mulberry Family

Morus ruba	Red mulberry
Morus alba	White mulberry
Maclura pomifera	Osage orange

URTICACEAE—Nettle Family

Parietaria pennslyvanica .... Pennsylvanian pellitory

POLYGONACEAE—Buckwheat Family

Eriogonum annum .... Annual erigonum
Rumex altissimus .... Tall or peach-leaved dock
Rumex crispus .... Curled or narrow dock
Polygonum buxiforme .... Shore knotweed
Polygonum lapathifolium ...... Dock-leaved or pale persicaria
Polygonum coccineum
  pratincolum .... Pink-flowered dock
Polygonum virginianum .... Virginia knotweed
Polygonum longistylum .... Long-styled persicaria
Polygonum punctatum .... Dotted or water smartweed
Polygonum convolvulus .... Black or corn bindweed
Polygonum scandens .... Climbing false buckwheat
Fagopyrum esculentum .... Buckwheat

AMARANTHACEAE—Amaranth Family

Amaranthus retroflexus .... Green Amaranth, redroot
Amaranthus spinosus .... Spiny or thorny Amaranth
Amaranthus blitoides .... Prostrate Amaranth
(?) Acnida tuberculata .... Rough-fruited water hemp
Acnida tamariscina .... Western water hemp
Froelichia campestris .... Prairie Froelichia
Froelichia gracilis .... Slender Froelichia

CHENOPODIACEAE—Goosefoot Family

Chenopodium album .... Lamb's quarters, white goosefoot
Chenopodium botrys .... Feather geranium, Jerusalem oak
Chenopodium leptophyllum .... Narrow-leaved goosefoot
Chenopodium boscianum .... Bosc goosefoot
Chenopodium gigantospermum
  (C. hybridum) .... Maple-leaved goosefoot
Cycloloma atriplicifolium ...... Winged pigweed
Monolepis nuttalliana .... Monolepis
Atriplex argentea .... Silvery orache
Salsola pestifer .... Russian thistle

PHYTOLACCACEAE—Pokeweed Family

Phytolacca decandra .... Pigeonberry, pokeweed

NYCTAGINACEAE—Four-o'Clock Family

Mirabilis linearis .... Narrow-leaved umbrellawort
Mirabilis albida .... Pale umbrellawort
Mirabilis nyctaginea .... Heart-leaved umbrellawort
Mirabilis nyctaginea ovata ..... Wide-leaved umbrellawort

AIZOACEAE—Carpetweed Family

Mollugo verticillata .... Carpetweed

PORTULACACEAE—Purslane Family

Talinum calycinum	Large flowered talinum
Portulaca oleracea	Purslane, pursley

ALSINACEAE—Chickweed Family

Arenaria serpyllifolia	Thyme-leaved sandwort
Stellaria media	Common chickweed
Cerastium brachypodum	Short-stalked chickweed

CARYOPHYLLACEAE—Pink Family

Silene antirrhina	Sleepy catchfly

RANUNCULACEAE—Crowfoot Family

Delphinium virescens	Prairie larkspur
Delphinium ajacis	Rocket larkspur
Anemone caroliniana	Carolina anemone
Myosurus minimus	Mousetail
Ranunculus abortivus	Kidney or smooth-leaved crowfoot
Viorna pitcheri	Pitcher's leatherflower

MENISPERMACEAE—Moonseed Family

Menispermum canadense	Canada moonseed

PAPAVERACEAE—Poppy Family

Argemone intermedia	Leafy white prickly poppy

FUMARIACEAE—Fumewort Family

Corydalis campestris	Plains corydalis
Corydalis montana	Mountain corydalis

BRASSICACEAE (CRUCIFERAE)—Mustard Family

Draba reptans	Carolina Whitlow grass
Draba reptans micrantha	Whitlow grass
Berteroa incana	Hoary alyssum
Camelina microcarpa	Small-fruited false flax
Radicula sinuata	Yellow cress
Capsella bursa-pastoris	Shepherd's purse
Rorippa sessiliflora	Sessile-flowered cress
Rorippa sinuata	Spreading yellow cress
Lepidium draba	Hoary cress (a very good weed to do without)
Lepidium densiflorum	Wild tongue or peppergrass
Lepidium ramosissimum	Lesser wart cress
Sophia intermedia	Western tansy mustard
Sophia pinnata	Tansy mustard
Arabis virginica	Virginia rock cress
Brassica nigra	Black mustard
Brassica juncea	Indian mustard
Brassica campestris	Turnip-wild navew

CAPPARIDACEAE—Caper Family

Cleomella angustifolia .... Northern cleomella
Polanisia trachysperma .... Large-flowered clammyweed

GROSSULARIACEAE—Gooseberry Family

Ribes odoratum .... Golden, buffalo or Missouri currant
Ribes missouriense .... Missouri gooseberry

PLATANACEAE—Plane Tree Family

Platanus occidentalis .... Plane tree, sycamore

ROSACEAE—Rose Family

Fragaria virginiana illinoensis... Wild strawberry
Geum virginianum .... Rough avens, bennet. herb bennet
Geum canadense camporum .... White avens
Geum vernum .... Spring avens
Geum strictum .... Yellow avens
Rubus ostryifolius .... Tall blackberry
Rubus occidentalis .... Black raspberry
Rose setigera .... Prairie rose
Rosa suffulta .... Wild rose

AMYGDALACEAE—Peach Family

Prunus angustifolia watsoni .... Chickasaw plum, hog plum

MIMOSACEAE—Mimosa Family

Desmanthus illinoensis .... Illinois mimosa
Scrankia uncinata .... Sensitive brier

CAESALPINIACEAE—Senna Family

Cercis canadensis .... Redbud, American Judas tree
Cassia marilandica .... Wild senna
Chamaecrista fasciculata .... Partridge pea, prairie senna
Gleditsia triacanthos .... Honey locust
Gymnocladus dioica .... Kentucky coffee tree

FABACEAE—Pea Family

Baptisia australis minor .... Blue false indigo
Baptisia leucophaea .... Yellow false indigo
Medicago sativa .... Alfalfa, lucerne, purple medic
Medicago lupulina .... Black or hop medic
Melilotus alba .... White sweet clover
Melilotus officinalis .... Yellow melilot, yellow sweet clover
Trifolium pratense .... Red, purple or meadow clover
Trifolium repens .... White clover
Lotus americanus .... Prairie bird's-foot trefoil
Psoralea tenuiflora .... Few-flowered psoralea
Psoralea floribunda .... Many-flowered psoralea

Psoralea digitata	Psoralea
Psoralea argophylla	Silverleaf psoralea
Psoralea esculenta	Pomme blanche
Psoralea cuspidata	Large bracted (Easternmost county)
Amorpha fruticosa (A. fragrans),	False or bastard indigo
Amorpha canescens	Lead plant, wild tea, shoestring
Petalostemum multiflorum	Round-headed prairie clover
Petalostemum purpureum	Violet or purple prairie clover
Petalostemum candidum	White prairie clover
Robina pseudoacacia	Black locust false acacia
Astragalus crassicarpus	Ground plum
Astragalus plattensis	Platte milk vetch
Oxytropis lamberti	Crazyweed or locoweed
Glycyrrhiza lepidota	Wild or American licorice
Desmodium illinoense	Illinois tick trefoil
Desmodium paniculatum	Panicled tick trefoil
Lespedeza capitata	Round-headed bush clover
Vicia villosa	Cow vetch
Vicia americana	American or purple vetch
Strophostyles helvola	Trailing wild bean
Strophostyles leiosperma	Small wild bean

GERANIACEAE—Geranium Family

Geranium carolinianum	Carolina crane's-bill

OXALIDACEAE—Wood Sorrel Family

Oxalis violacea	Violet wood sorrel
Oxalis stricta	Upright wood sorrel
Oxalis bushii	Bush wood sorrel

LINACEAE—Flax Family

Linum lewisii	Lewis wild flax

ZYGOPHYLLACEAE—Caltrop Family

Tribulus terrestris	Puncture vine, ground burnut, land caltrop

POLYGALACEAE—Milkwort Family

Polygala verticillata	Whorled milkwort
Polygala incarnata	Pink milkwort

EUPHORBIACEAE—Spurge Family

Croton glandulosus	Glandular croton
Croton capitatus	Capitate croton
Croton monanthogynus	Single-fruited croton
Tragia ramosa	Branching tragia
Stillingia salicifolia	Queen's delight, queenroot
Euphorbia petaloidea	White-flowered spurge
Euphorbia stictospora	Narrow-seeded spurge

Euphorbia serpens	Round-leaved spreading spurge
Euphorbia nuttallii	White-flowered spurge
Euphorbia serpyllifolia	Thyme-leaved spurge
Euphorbia albicaulis	White-stemmed spurge
Euphorbia stictospora	Narrow-seeded spurge
Euphorbia maculata	Milk purslane, spotted spurge
Euphorbia hyssopifolia	Upright spotted spurge
Euphorbia glyptosperma	Spurge
Euphorbia hexagona	Angled spurge
Euphorbia marginata	White-margined spurge
Euphorbia dictyosperma	Reticulate-seeded spurge
Euphorbia corollata	Flowering spurge
Euphorbia cuphosperma	Warty spurge
Euphorbia dentata	Toothed spurge

ANACARDIACEAE—Sumac Family

Rhus typhina laciniata	Staghorn sumac (escaped)
Rhus glabra	Smooth, upland or scarlet sumac
Rhus toxicodendron radicans....	Poison ivy

ACERACEAE—Maple Family

Acer negundo	Boxelder, ashleaf maple

CELASTRACEAE—Staff-Tree Family

Celastrus scandens	Shrubby or climbing bittersweet

VITACEAE—Grape Family

Vitis vulpina	Chicken grape
Vitis cordifolia	Frost grape
Vitis longii	Wild grape
Ampelopsis cordata	Simple-leaved ampelopsis
Parthenocissus quinquefolia	Virginia creeper

MALVACEAE—Mallow Family

Malva neglecta	Low, dwarf or running mallow
Callirhoe alceoides	Light poppy mallow
Callirhoe involucrata	Purple poppy mallow
Sida spinosa	Prickly sida, Indian or false mallow
Abutilon theophrasti	Velvet leaf, Indian mallow
Hibiscus militaris	Halbred-leaved rose mallow
Hibiscus trionum	Blodder ketmia, flower-of-an-hour

VIOLACEAE—Violet Family

Viola papilionacea	Meadow or hooded blue violet
Viola missouriensis	Missouri violet
Viola rafinesquii	Field pansy

LOASACEAE—Loasa Family

Mentzelia stricta	Stiff nuttalia

CACTACEAE—Cactus Family

Opuntia. humifusa	Western prickly pear, devil's tongue
Opuntia camanchica	Comanche cactus

LYTHRACEAE—Loosestrife Family

Ammannia coccinea	Long-leaved ammannia
Lythrum alatum	Wing-angled loosestrife

ONAGRACEAE—Evening Primrose Family

Jussiaea diffusa	Floating or creeping primrose willow
Oenothera missouriensis	Missouri primrose
Oenothera strigosa	Evening primrose
Oenothera laciniata	Cut-leaved evening primrose
Oenothera rhombipetala	Rhombic evening primrose
Hartmannia speciosa	Showy evening primrose
Meriolix serrulata	Tooth-leaved evening primrose
Gaura parviflora	Small-flowered Gaura

AMMIACEAE—Carrot Family

Sanicula canadensis	Short-styled snakeroot
Daucus carota	Wild carrot
Chaerophyllum procumbens	Spreading chervil
Chaerophyllum texanum	Chervil
Lomatium daucifolium	Carrot-leaved parsley
Pleiotaenia nuttallii	Nuttall prairie parsley
Spermolepis patens	Spreading spermolepis
Conium maculatum	Poison hemlock

CORNACEAE—Dogwood Family

Cornus asperifolia	Rough-leaved cornel or dogwood

PRIMULACEAE—Primrose Family

Androsace occidentalis	Androsace

OLEACEAE—Olive Family

Fraxinus pennsylvanica lanceolata	Green ash
Fraxinus pennsylvanica	Red ash

APOCYNACEAE—Dogbane Family

Amsonia tabernaemontana	Amsonia
Apocynum cannabinum	Indian hemp army root
Apocynum sibiricum	Clasping-leaved dogbane
Apocynum cordigerum	Dogbane

ASCLEPIADACEAE—Milkweed Family

Asclepias tuberosa	Butterfly weed
Asclepias latifolia	Broad-leaved milkweed
Asclepias speciosa	Showy milkweed

Asclepias amplexicaulis	Blunt-leaved milkweed
Asclepias incarnata	Swamp milkweed
Asclepias verticillata	Whorled milkweed
Asclepiodora viridis	Oblong-leaved milkweed
Acerates viridiflora	Green milkweed
Acerates augustifolia	Narrow-leaved milkweed
Gonolobus laevis	Sand vine, Enslen's vine

CONVOLVULACEAE—Morning Glory Family

Evolvulus nuttallianus	Evolvulus
Ipomoea leptophylla	Bush morning-glory
Ipomoea purpurea	Morning-glory
Ipomoea hederacea	Ivy-leaved morning-glory
Convolvulus arvensis	Field bindweed
Convolvulus interior	Trailing or hairy bindweed

CUSCUTACEAE—Dodder Family

Cuscuta pentagona	Dodder
Cuscuta cuspidata	Cuspidate dodder
Cuscuta glomerata	Glomerate or American dodder

HYDROPHYLLACEAE—Waterleaf Family

Ellisia nyctelea	Nyctelea

BORAGINACEAE—Borage Family

Myosotis virginica	Spring or early scorpion grass
Lithospermum linearifolium	Narrow-leaved puccoon
Onosmodium occidentale	Western false cromwell

VERBENACEAE—Vervain Family

Verbena urticaefolia	White or nettle-leaved vervain
Verbena hastata	Blue or false vervain, wild hyssop
Verbena stricta	Large-bracted vervain
Lippia cuneifolia	Wedge-leaved fogfruit
Lippia lanceolata	Fogfruit

LAMIACEAE (LABIATAE)—Mint Family

Teucrium canadense	American germander
Nepeta cataria	Catmint, catnip
Lamium amplexicaule	Henbit
Salvia pitcheri	Pitcher sage, tall sage
Salvia reflexa (S. lanceolata)	Lance-leaved sage
Salvia sylvestris	Sage
Monarda mollis	Pale wild bergamot
Monarda punctata	Horsemint
Monarda citriodora	Plains lemon monarda
Hedeoma hispida	Rough pennyroyal
Mentha piperita	Peppermint

SOLANACEAE—Potato Family

Physalis longifolia .... Long-leaved ground cherry
Physalis macrophysa .... Large-bladder ground cherry
Physalis lanceolata .... Prairie ground cherry
Physalis pumila .... Low ground cherry
Solanum elaeagnifolium .... Silver-leaved nightshade
Solanum carolinense .... Horse nettle, sand brier
Solanum rostratum .... Buffalo bur, sandbur
Datura stramonium .... Jimson weed

SCROPHULARIACEAE—Figwort Family

Linaria vulgaris .... Butter-and-eggs, Ranstead
Penstemon cobaea .... Cobaea beard tongue
Mimulus glabratus fremontii ... Yellow monkey flower
Leucospora multifida .... Conobea
Veronica peregrina xalapensis ... Speedwell neckweed

BIGNONIACEAE—Trumper Creeper Family

Catalpa speciosa .... Western catalpa

MARTYNIACEAE—Unicorn Plant Family

Martynia louisianica .... Unicorn plant, elephant's trunk

ACANTHACEAE—Acanthus Family

Ruellia strepens .... Smooth or short-tube ruellia
Ruellia caroliniensis (R. ciliosa), Hairy or long-tube ruellia
Dianthera americana .... Dense-flowered water willow

PLANTAGINACEAE—Plantain Family

Plantago major .... Common or greater plantain
Plantago rugelii .... Rugel or pale plantain
Plantago purshii .... Pursh plantain
Plantago elongata .... Slender plantain
Plantago virginica .... Dwarf or white dwarf plantain

RUBIACEAE—Madder Family

Houstonia minima .... Least bluets
Houstonia angustifolia .... Narrow-leaved houstonia
Cephalanthus occidentalis ...... Bottonbush, honey-balls, globe flower
Diodia teres .... Rough buttonweed
Galium vaillanthii .... Vaillant's goose grass or cleavers
Galium circaezans .... Wild liquorice or cleavers

CAPRIFOLIACEAE—Honeysuckle Family

Sambucus canadensis .... American elder
Symphoricarpos orbiculatus .... Coralberry, Indian currant
Lonicera glaucescens .... Douglas honeysuckle

CUCURBITACEAE—Gourd Family

Pepo foetidissima .... Missouri gourd, wild pumpkin

CAMPANULACEAE—Bellflower Family

Specularia perfoliata .... Venus looking glass
Specularia leptocarpa .... Western Venus looking glass

LOBELIACEAE—Lobelia Family

Lobelia splendens .... Cardinal flower, red Betty

CICHORIACEAE—Chicory Family

Lactuca virosa .... Prickly or wild lettuce
Serinia oppositifolia .... Serinia
Tragopogon pratensis .... Yellow goat's bread
Tragopogon porrifolius .... Salisfy, purple goat's bread
Cymbia occidentalis .... Western dwarf dandelion
Taraxacum vulgare .... Dandelion
Sonchus asper .... Spiny or sharp-fringed sow thistle
Lactuca serriola (L. scariola).... Prickly or wild lettuce
Agoseris cuspidata .... Prairie false dandelion
Pyrrhopappus carolinianus ...... Leafy-stemmed false dandelion
Pyrrhopappus grandiflorus ...... Rough false dandelion
Hieracium longipilum .... Long-bearded hawkweed

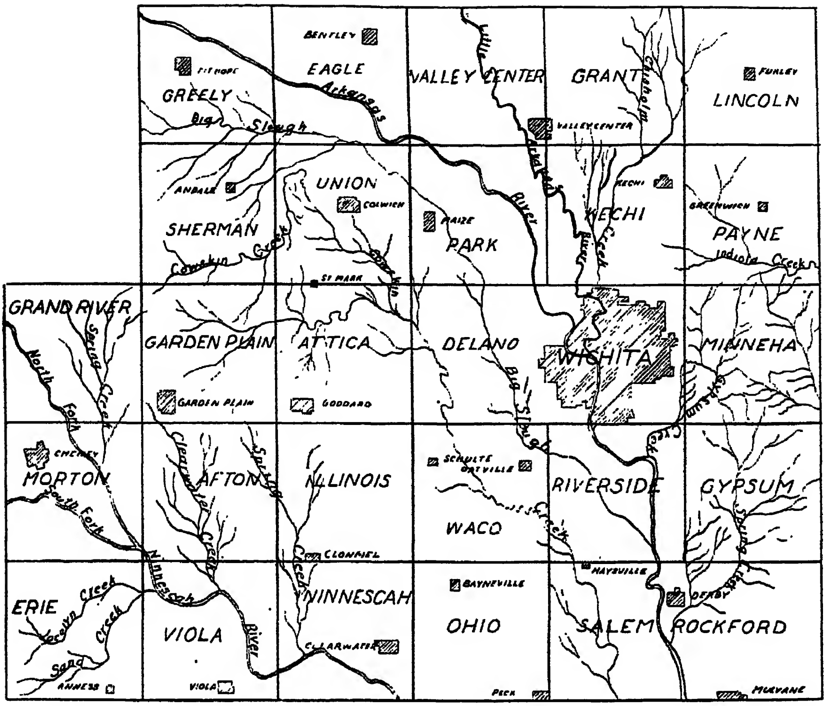
AMBROSIACEAE—Ragweed Family

Ambrosia trifida .... Giant ragweed, horse-cane
Ambrosia elatior .... Ragweed
Ambrosia psilostachya .... Western ragweed
Xanthium pennsylvanicum ..... Cocklebur

COMPOSITAE—Thistle Family

Vernonia fasciculata .... Western ironweed
Vernonia interior .... Ironweed
Eupatorium altissimum .... Tall thoroughwort
Eupatorium rugosum (E urticaefolium) .... White snakeroot
Kuhnia suaveolens .... False boneset
Kuhnia hitchcockii .... False boneset
Liatris punctata .... Blazing star
Liatris aspera .... Button snakeroot
Amphiachyris dracunculoides ... Amphiachyris, broomweed
Chrysopsis sp. .... Golden aster
Prionopsis ciliata .... Prionopsis
Sideranthus spinulosus .... Cut leaved sideranthus
Isopappus divaricatus .... Isopappus
Solidago canadensis gilvocanescens .... Canada or rock goldenrod
Solidago glaberrima .... Missouri goldenrod

Solidago serotina	Late goldenrod
Solidago longipetiolata	Tall, high or double goldenrod
Solidago rigida	Stiff or hard-leaved goldenrod
Aster oblongifolius	Aromatic aster
Aster ericoides	White heath aster
Aster exilis	Slim aster
Erigeron ramosus	Daisy fleabane
Erigeron canadensis	Horseweed, Canada fleabane
Baccharis neglecta	Linear-leaved baccharis
Antennaria campestris	Prairie cat's-foot
Silphium speciosum	Entire-leaved rosinweed
Silphium laciniatum	Compass plant, pilot weed
Eclipta alba	Yerba de tajo
Rudbeckia hirta	Black-eyed Susan, yellow daisy
Ratibida columifera	Long-headed or prairie cone flower
Echinacea angustifolia	Narrow-leaved purple cone flower
Helianthus annuus	Common sunflower
Helianthus petiolaris	Prairie sunflower
Helianthus maximiliani	Maximilian sunflower
Helianthus tuberosus	Jerusalem artichoke
Actinomeris alternifolia	Wingstem, yellow ironweed
Coreopsis tinctoria	Golden coreopsis
Tetraneuris fastigiata	Narrow-leaved tetraneuris (Easternmost record)
Hymenopappus tenuifolius	Wolly white hymenopappus
Hymenopappus scabiosaeus	Yellow hymenopappus
Gaillardia pulchella	Showy gaillardia
Boebera papposa	Fetid marigold, false dog fennel
Achillea millefolium	Yarrow, milfoil
Achillea lanulosa	Wooly yarrow
Artemisia cernua	Wormwood
Artemisia absinthium	Common wormwood
Artemisia annua	Annual wormwood
Artemisia ludoviciana	Dark-leaved mugwort
Artemisia graphalodes	Prairie or western sage
Cacalia tuberosa	Tuberous Indian plantain
Senecio plattensis	Prairie ragwort
Cirsium lanceolatum	Common bur or spear thistle
Cirsium altissimum	Tall or roadside thistle
Cirsium undulatum	Wavy-leaved thistle
Cirsium ochrocentrum	Yellow-spined thistle



Map of Sedgwick county, showing names and outlines of townships and locations of rivers and streams, as well as cities and towns

The Fleshy Fungi of Crawford County, Kansas

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One hundred twenty species of fleshy fungi have been collected and identified in Crawford county, Kansas. These were divided among four orders, thirteen families and fifty-nine genera, fifty-five of which were edible, eleven poisonous and fifty-four woody or undesirable.

The more common poisonous species found were: Amanita phalloides, Amanita flavoconia, Amanita rubescens, Lepiota morgani, Ithyphallus impudicus, Ithyphallus rubescens and Mutinus caninus.

The more common edible species included Agaricus campestris, Agaricus arvensis, Cantharellus cibarius, Cantharellus cinnabarinus, Collybia velutipes, Coprinus comatus, Coprinus atramentarius, Coprinus micaceus, Pluteus cervinus, Pleurotus ostreatus, Pleurotus sapidus, Pleurotus ulmarius, Lactarius volemus, Lactarius deliciosus, Morchella conica, Lycoperdon pyriforme, Lycoperdon gemmatum, Lycoperdon wrighti and Russula virescens. Many others are edible, but are too small or not common enough to mention.

LIST OF FLESHY FUNGI OF CRAWFORD COUNTY

Family Agaricaceae

Amanitopsis vaginata badia Roze (edible); May-September.
Amanitopsis volvata (Pk.) Sacc. (poisonous); June-August.
Amanita flavoconia (poisonous); June-August.
Amanita phalloides (Vaill) Fr. (poisonous); May-September.
Amanita rubescens Pers. (poisonous); June-September.
Lepiota morgani Pk. (poisonous); August-November.
Lepiota cristate (A. & S.) (edible); May-September.
Pleurotus ulmaris (Bull) Fr. (edible); September-December.
Pleurotus ostreatus (Jacq.) Fr. (edible); May-October.
Pleurotus sapidus (edible); June-December.
Cantharellus cibarius (edible); June-September.
Cantharellus cinnabarinus (edible); May-September.
Craterellus cantharellus (Schw.) Fr. (edible); June-September.
Clitocybe infundibuliformis (Schaeff) Fr. (edible); May-September.
Clitocybe ochropurpurea (Berk) (edible); April-September.
Clitocybe multiceps Peck (edible); May-September.
Collybia velutipes (Curt) Fr. (edible); all year.
Collybia longipes (Bull) Berk (edible); June-September.
Collybia radicata (Rehl) Berk (edible); June-September.
Collybia platyphylla (Pers.) Quel. (edible); June-September.
Collybia dryophila Qual. (edible); May-September.
Lactarius piperatus (Scop) Fr. (edible); June-September.
Lactarius volemus Fr. (edible); June-September.
Russula emetica (Schaff) Fr. (edible); May-September.
Russula virescens Fr. (edible); May-September.
Russula foetens (Pers.) Fr. (not edible); May-September.
Marasmius rotula (Scoop) Fr. (edible); June-October.
Marasmius candidus Murr; June-October.
Marasmius cohaerens Fr.; June-October.
Panus stipticus Fr. (not edible); May-September.
Panus rudis Fr. (edible); April-November.

Claudopus nidulans (Pers.) Pk. (edible); May-September.
Pluteus cervinus (Sch.) Quel. (edible); June-September.
Pluteus admirabilis; June-September.
Galera tenera Schaff (edible); May-August.
Paxillus rhodoxanthus Schw. (edible); June-September.
Pholiota adiposa Fr. (edible); June-September.
Agaricus campestria (L.) Fr. (edible); June-September.
Agaricus rodmani Pk. (edible); June-September.
Agaricus arvensis Fr. (edible); July-September.
Stropharis semiglobata (Batch) Fr. (edible); May-September.
Hypoloma incertum Pk. (edible); May-September.
Coprinus micaceus (Bull) Fr. (edible); March-October.
Coprinus comatus (Fl. Dan.) Fr. (edible); August-October.
Coprinus atramentarius Fr. (edible); April-October.
Panaeolus solidipes Pk. (undesirable); May-September.
Panaeolus retirugis Gr. (undesirable); May-August.

Family Polyporaceae

Trametes hispida Bolg. (woody); all year.
Polyporus picipes Fr. (woody); June-September.
Polyporus frondosus Fr. (edible); July-October.
Polyporus arcularius (not edible); May-October.
Polyporus lucidus (not edible); June-December.
Polyporus sanguineus (L.) Fr. (woody); all year.
Polyporus nidulans Fr. (woody); June-October.
Polyporus hirsutus (Wulf) Fr. (woody); all year.
Polyporus pargamenus Fr. (woody); all year.
Polyporus gilvus (Schw.) Fr. (woody); all year.
Polyporus dichrous Fr. (undesirable); June-October.
Polyporus albellus Pk. (undesirable); June-October.
Polyporus versicolor (L.) Fr. (woody); all year.
Polyporus brumalis Fr. (woody); June-October.
Polyporus biformis (Kl.) (woody); all year.
Polyporus sulphureus Fr. (edible); all year.
Polyporus cinnabarinus Jacw. (woody); all year.
Favolus alveolaris Quel. (woody); May-October.
Daedalea ambigua Berk. (woody); May-November.
Fomes everhartii Ell. and Gall; all year.
Fomes applantus Gill (woody); all year.
Strobilomyces strobilaceus (Scop.) Berk. (edible); June-September.
Boletus bicolor Pk.; June-September.

Family Tremellaceae

Exidia alba (Lloyd) Burt (questionable); May-October.
Auricularia aricula (L.) Schroet (edible); ————
Tremellodon gelatinosum Mcl. (edible); June-September.

Family Clavaricaeae

Clavaria pyxidata Fr. (edible); June-September.
Clavaria flava Fr. (edible); June-September.

Family Thelephoraceae

Stereum fasciatum Schw. (woody); all year.
Craterellus cantharellus (Schw.) Fr. (edible); June-September.
Craterellus cornucopioides (L.) Fr. (edible); June-September.

Family Hydnaceae

Irpex mollis B. and C. (woody); all year.
Hydnum coralloides Fr. (edible); July-November.

Family Phallaceae

Ithyphallus impudicus (L.) Fr. (poisonous); June-October.
Mutinus caninus Fr. (poisonous); May-September.

Family Lycoperdaceae

Secotium agaricoides (Czern.) H. (undesirable); August-October.
Geaster hygrometricus Pers. (edible); June-October.
Geaster saccatus Fr. (edible); June-October.
Calvatia Cyathiformis (Bosc.) Morgan (edible); July-October.
Calvatia craniformis Fr. (edible); July-October.
Lycoperdon pyriforme (Schaeff) Pers. (edible); May-September.
Lycoperdon gemmatus Batch (edible); May-September.
Lycoperdon wrighti B. and C. (edible); May-September.

Family Nidulariaceae

Cyathus olla (Batsch) Pers.; May-September.
Crucibulum vulgare Gill; May-September.

Order Sphaeriales

Cordyceps melolanthae (not edible); June-July.
Xylaria polymorpha (not edible); June-December.
Xylaria hypoxylon (V. L. S.) (not edible); June-December.
Daldina concentrica (Bolt.) (not edible); May-October.

Family Helvellaceae

Morchella conica Pers. (edible); April.
Gyromitra esculenta (Pers.) Fr. (poison); April-May.
Helvella lacunosa Afz. (edible); June-September.
Leotia lubrica (Scop.) Pers. (edible); June-September.

Family Bulgariaceae

Bulgaria inquianans (edible); June-July.

Family Pezizaceae

Plectanis occidentalis (Schw.) Seaver; May-September.

SYNOPSIS OF THE GENERA OF FLESHY FUNGI OF CRAWFORD COUNTY

ORDER AGARICALES:

Fungi bearing spores on exposed hymenium.

FAMILY AGARICACEAE: Fungi with gills.

A. White spored series.
  1. Plants soon decaying.
    2. Volva present.
      3. Ring present .... Amanita.
      3. Ring absent .... Amanitopsis.
    2. Volva absent.
      3. Ring present .... Lepiota.
      3. Ring absent.
        4. Stem eccentric or lateral........................ Pleurotus.
        4. Stem central.
          5. Gills decurrent.
            6. Edges sinuate .... Laccaria.
            6. Edges rounded or absent.................. Cantharellus.
            6. Edges thin, stem fibrous.................. Clitocybe.
          5. Gills adnate.
            6. Cap fleshy .... Collybia.
            6. Cap fleshy, brittle, stem large.
              7. Milk present .... Lactarius.
              7. Milk absent .... Russula.
  1. Plants tough, easily dried, reviving when moist.
    2. Stem central, gills thin............................ Marismius.
    2. Stem eccentric, lateral, central or wanting.
      3. Edge of gills toothed or serrated.................. Lentinus.
      3. Edge of gills smooth............................ Panus.
      3. Edge of gills split............................. Schizophyllum.
  1. Plant corky, gills radiating............................ Lenzites.

B. Rosy spored series.
  1. Stem eccentric or absent, cap lateral..................... Claudopus.
  1. Stem central, gills free................................ Pluteus.

C. Yellow or brown spored series.
  1. Gills easily separated from cap, and decurrent, margin incurved .... Paxillus.
  1. Gills not easily separated from cap, ring present........... Pholiota, Galera.

D. Purple-brown spored series, volva absent.
  1. Ring present.
    2. Gills free .... Agaricus.
    2. Gills not free.................................... Stropharia.
  1. Ring absent, veil on cap................................ Hypholoma.

E. Black spored series, volva absent.
  1. Ring present, plants inky............................... Coprinus.
  1. Ring absent, cap smooth................................ Panaeolus.

FAMILY POLYPORACEAE: Fungi bearing spores in pores.

1. Substance of cap descending between pores.............. Trametes.
1. Substance of cap not descending......................... Polyporus.
1. Stem lateral, pores large-hexagonal....................... Favolus.
1. Stem wanting, lamellae labyrinthine...................... Daedalea.
1. Pores in stratified layers............................... Fomes.
1. Pores separable from cap............................... Boletus.
1. Cap rough, spores black................................ Strobilomyces.

Family Tremellaceae: Gelatinous fungi.

1. Fruit body globose .... Exida.
1. Fruit body branched, clavaria-like .... Tremellodendron.
1. Fruit body attached laterally, toothed .... Tremellodon.
1. Fruit body partitioned and ear-shaped .... Auricularia.

Family Clavariaceae: Club shaped fungi.

1. Fruit body smooth and layered .... Stereum.
1. Fruit body lobed, leathery .... Thelephora.
1. Fruit body funnel shaped .... Craterellus.

Family Hydnaceae: Fungi with teeth.

1. Fruit body branched, teeth entire .... Hydnum.
1. Fruit body leathery .... Irpex.

Order LYCOPERDALES:

Spores borne within a container.

Family Phallaceae: Spores borne in ill-smelling substance.

1. Gleba borne on stem without veil .... Ithyphallus.
1. Gleba borne on naked apex .... Mutinus.

Family Lycoperdaceae: Spores developed as dry powder.

1. Peridium rounded to conical .... Secotium.
1. Peridium borne on a stem .... Tylostoma.
1. Outer peridium star-shaped .... Geaster.
1. Inner peridium cork-like .... Mycenastrium.
1. Peridium opening through definite mouth .... Lycoperdon.
1. Peridium irregularly rupturing .... Calvatia.

Family Nidulariaceae: Fungi resembling bird nests.

1. Peridium of one layer and attached eggs .... Crucibulum.
1. Peridium of three layers and eggs attached .... Cyathus.

Order SPHAERIALES:

Spores borne in tiny embedded containers.

1. Stroma growing from dead insects .... Cordyceps
1. Stroma club shape .... Xylaria.
1. Stroma zoned within .... Daldina.

Order PEZIZALES:

Spore containers clothe fruit body.

Family Helvellaceae: Cap ridged, saddle or bell shaped.

1. Cap ridged .... Morchella.
1. Cap brain shaped .... Gyromitra.
1. Cap saddle shaped .... Helvella.

Family Geoglossaceae.

1. Plants small and sticky or gelatinous .... Leotia.

Family Bulgariaceae

1. Fruit body of gelatinous-elastic material, cup shape .... Bulgaria.

Family Pezizaceae: Fruit body cup shaped.

1. Fruit body leathery .... Urnula.
1. Fruit body hairy .... Sarcoscypha.

The Status of *Cylindrosporium chrysanthemi* E. and D., as the Causative Agent of Chrysanthemum Leaf Blight

J. A. TRENT, State Teachers College, Pittsburg, Kan.

The cause of chrysanthemum leaf blight is attributed to the fungus *Cylindrosporium chrysanthemi* E. and D., and is described by Ellis and Everhart (*1*) as follows: "Spots large (1 cm. or more), subindefinite, nearly black. Acervuli immersed, 100-170 mu. in diameter. Conidia fusoid, nearly straight, 50-150 x 3-4½ mu., issuing copiously on both surfaces of the leaf. On leaves of Chrysanthemum Sinense . . ." It was the purpose of this investigation to determine if the fungus as described is the causative agent of chrysanthemum leaf blight.

MATERIALS AND METHODS

Leaves of chrysanthemum infected with the fungus were available from Georgia, collected by C. C. Boyd; London, Ontario, Canada, collected by J. Dearness; Connecticut, collected by G. P. Clinton; Purdue University (Indiana) Floriculture greenhouses; the Pennsylvania State College Herbarium, collected by Orton and Nixon; and from the Fungi Columbiana No. 84 deposited in the Cryptogamic Herbarium of the University of Illinois. All material, except that from Purdue University, was herbarium material. The herbarium material was prepared for sectioning by first soaking in lacto-phenol (lactic acid 20 grams, phenol crystals 20 grams, glycerine 40 grams, and water 20 cc.) for a day or so, after which it was washed in running water for several hours, dehydrated in the alcohols and embedded in paraffin in the usual manner. Sections were cut 10 mu. in thickness and stained in Pianese III B, by the method as described by Vaughan (*3*). This stain gives good differentiation between host and parasite even in herbarium material. Measurements were made of the conidia-bearing structures and of the conidia for all specimens.

OBSERVATIONS AND RESULTS

Figure 1 shows leaves of a cultivated chrysanthemum infected with the blight fungus, which outwardly correspond closely with the description given by Ellis and Everhart (*1*), Stevens (*2*), and others. However, microscopic examination of slides show pycnidia, as represented by figures 2-5. In none of the material examined, were typical acervuli found. The pycnidia are found on both sides of the leaf. Conidia were observed escaping through the ostiole. Some of the pycnidia have a short beak. (Fig. 5.) The pycnidia are subepidermal. The pycnidia range in size (median sections) from 85-175 mu. in diameter. The conidia range in size from 30-70 x 1-2.5 mu. The conidia are straight or slightly curved, somewhat spindle-shaped, appear granular, and sometimes obscurely septate. These measurements agree with those given for the acervuli of *Cylindrosporium chrysanthemi* E. and D., but differ markedly in conidia measurements.

From the foregoing observations it is concluded that *Cylindrosporium*

Trans. Kansas Acad. Science, Vol. 42, 1939.

chrysanthemi E. and D., reported as the causative agent of chrysanthemum leaf blight, has more characteristics in common with the genus Septoria than it has with Cylindrosporium, and should be considered a synonym of *Septoria chrysanthemi* Cav. (S. chrysanthemella Cav. [Sacc.]), or *S. chrysanthemi* Allesch.

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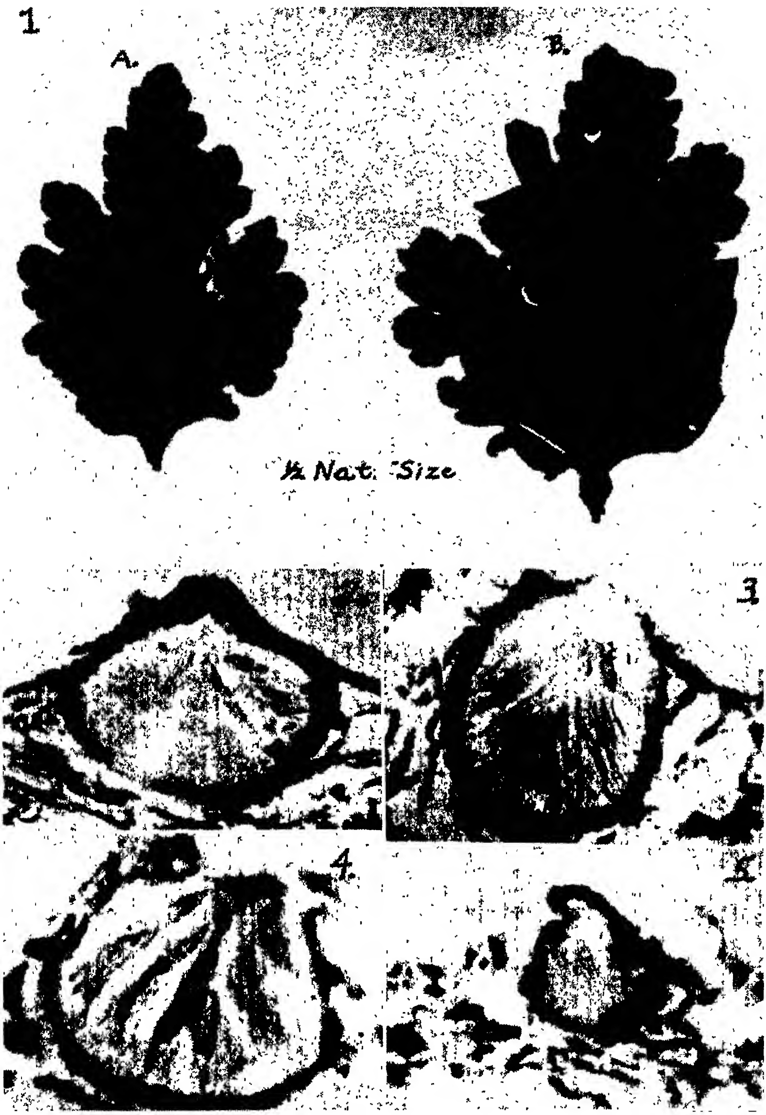
3. Vaughan, R. E. A Method for the Differential Staining of Fungus and Host Cells. Ann. Mo. Bot. Gard. 1:241-242. 1914.

EXPLANATION OF PLATE

FIG. 1. Leaves of chrysanthemum infected with *Septoria chrysanthemi* Cav. A. Upper side of leaf. B. Lower side of leaf. (Courtesy C. C. Boyd of Georgia.)

FIGS. 2-5. Pycnidia from various specimens. 2. London, Ontario, Canada. 3. Purdue University. 4. Georgia (Taken from leaf B. in Fig. 1). 5. From the Fungi Columbiana No. 84.

FIGURES 1 TO 5



Festuca octoflora var. *hirtella*, a New Grass for Kansas

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Festuca octoflora var. *hirtella* Piper was first found by Dr. F. W. Albertson while he was making ecological studies in the College pasture, two miles west of Hays, Kan. Confirmation of identification was made by Mrs. Agnes Chase, senior botanist, Bureau of Plant Industry, who stated that this was the first record of the grass having been found in Kansas. Previously, this variety had been known only from the Southwest and Pacific Coast, mostly occupying arid or semiarid situations. A. S. Hitchcock (Manual of the Grasses of the United States) states that its range is from Texas to Southern California, southward to Baja California, and northward to Nevada, Montana, and Washington.

Although the variety greatly resembles the species, *Festuca octoflora* Walt., there are contrasting characteristics of the two which are significant. The most marked difference is in height. Obviously this cannot be an ecological change as a result of environmental conditions, because the variety and the species are found growing side by side in the shortgrass habitat. Mrs. Chase further stated that this was the first record of the two found growing together.

A study of 100 specimens of each plant from the College pasture shows that the average height of the species is 40 cm., as compared to 25 cm. for the variety, while the tallest specimen of each grass measued 55 cm. and 35 cm., respectively. Both, however, were found to be as short as 15 cm., though there were fewer of the species than of the variety of this height. The sheaths and blades of *Festuca octoflora hirtella* are finely pubescent. Its inflorescence is a compressed panicle resembling that of *Festuca octoflora,* except that it is even more compact, the secondary branches are shorter, less branched, and the spikelets tend to become arranged on one side of the rachis. The head of the variety contains fewer spikelets, and is usually only one-third as long as that of the species. The florets of *F. octoflora hirtella* are bristly with a rough pubescence. The lemmas bear a relatively long awn, and the florets tend to grow in a divaricate manner, presenting a larger angle to the rachilla. In the species, these characteristics are not found, or are greatly altered. It has also been noted that the variety matures several days ahead of the species.

In the plants studied, it was found that there is an average of 7 florets per spikelet in the species as compared to 10 in the variety. The range in number of florets per spikelet seemed to deviate very little from the average. The length and width of the spikelets are identical. However, the average length of the lemma of *F. octoflora* is 4 mm., while that of the variety is 3 mm., but it has in addition an awn 2 mm. long. The species is awnless or nearly so. The presence of the awns makes the spikelets of the variety look larger.

Trans. Kansas Acad. Science, Vol. 42, 1939.

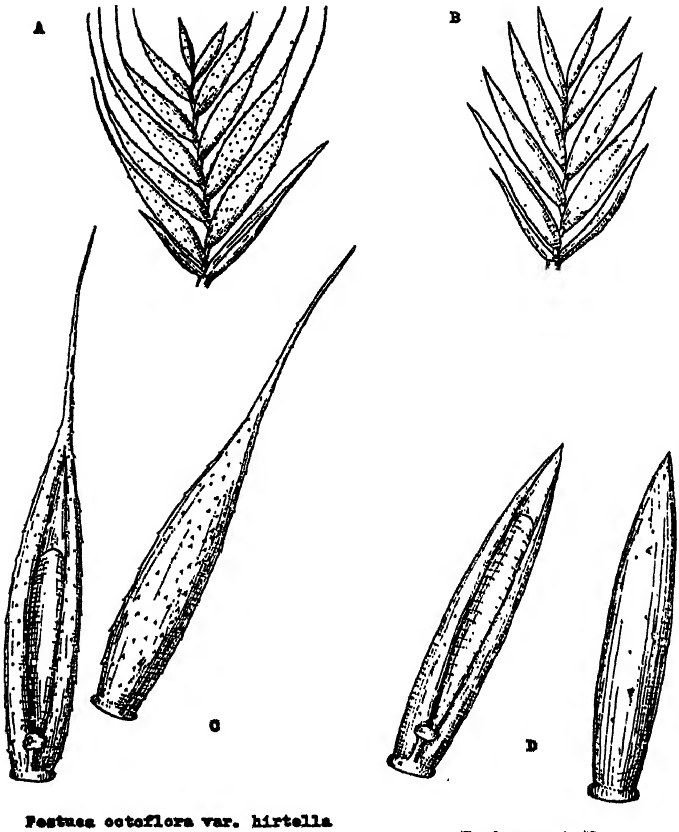

FIGURE 1. Enlarged views of a typical spikelet and of the ventral and dorsal sides of florets of *Festuca octoflora* var. *hirtella* (A, C) and of *Festuca octoflora* (B, D).

Two Beta Arsenical Derivatives of Naphthalene

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BETA-NAPHTHYL ARSONIC ACID

Beta-naphthyl arsonic acid was described by Michaelis[1] as needles melting at 155° C. As the isomeric alpha-naphthyl-arsonic acid melts at 197° and beta-isomers commonly have higher melting points than the alpha-isomers, the value of Michaelis appears to be questionable. Michaelis prepared his product from mercury di-beta-naphthyl and arsenious chloride, followed by chlorination and finally hydrolysis, as indicated in the following equations.

$$2\ AsCl_3 + (C_{10}H_7)_2Hg \rightarrow 2\ C_{10}H_7AsCl_2 + HgCl_2$$
$$C_{10}H_7AsCl_2 + Cl_2 \rightarrow C_{10}H_7AsCl_4$$
$$C_{10}H_7AsCl_4 + 3\ H_2O \rightarrow C_{10}H_7AsO(OH)_2 + 4\ HCl$$

In the first step, a temperature of 130° C., and in the second, a temperature of 80° C., was employed to complete the reaction. It is quite possible that some migration of the arsenic groups occurred at such temperatures. Mixtures of alpha and beta-naphthyl arsonic acids have been made in this laboratory which melted as low as 159° C. (minimum melting point given by equimolecular mixture), so that a mixture of the two isomers might have given the melting point reported by Michaelis.

When beta-naphthyl arsonic acid was prepared by adding diazotized beta-naphthylamine to an aqueous solution of sodium arsenite followed by allowing the mixture to decompose at room temperature, a product which does not melt below 300° C. was obtained. This procedure definitely introduces the arsonic acid group into the beta position, in accordance with the following equation:

$$R{-}N{=}N{-}X + Na_2HAsO_3 \rightarrow R{-}AsO_3HNa + N_2 + NaX$$

Preparation of beta-naphthylarsonic acid: In 300 ml. of boiling water was suspended 0.1 mol of beta naphthylamine (14.3 g.). Just enough hydrochloric acid was added to bring the amine into solution. With rapid stirring the solution was cooled to 0° C. and enough more cencentrated hydrochloric acid added to bring the total amount of acid to 20 ml. To the resultant cold suspension of beta naphthylamine hydrochloride was added rapidly at 10 percent solution of 0.1 mol of sodium nitrite (6.9 g.), keeping the temperature between 0° and 5° C. The solution was stirred for one-half hour after addition of sodium nitrite was completed. The cold diazo solution was added with rapid mechanical stirring to a solution of 0.4 mol of sodium meta arsenite (58.4 g.) and a small crystal of copper sulfate in 200 ml. of water and crushed ice. The resultant solution should be alkaline to litmus paper. The decomposition of the diazonium compound proceeds slowly. The solution therefore was allowed to stand for ten days with occasional stirring, after which it

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Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Michaelis, Annalen der Chemie: 320, 344 (1902).

14—76

was filtered through a charcoal pad. The filtrate was made just acid to Congo red paper. After standing for one hour in the icebox, the suspended arsonic acid was collected by filtration, purified by reprecipitation from ice-cold sodium bicarbonate solution, and dried at 110° C. The arsonic acid is a white crystalline solid soluble in hot water, but slightly soluble in cold water. It does not melt or decompose below 300° C.

Yield, 6.6 g. (26.2 percent of the theoretical yield.)

Analysis[2]: 29.72 percent, 29.74 percent arsenic. Theoretical value, 29.75 percent arsenic.

Hypophosphorous acid converted the arsonic acid into the corresponding arseno beta naphthalene melting at 244° C. Refluxing with concentrated hydrobromic acid yielded beta bromonaphthalene.

BETA NAPHTHYLAMINE HYDROGEN ARSENATE

Boon and Ogilvie[3] have described the mechanism of the application of the Béchamp reaction to alpha-naphthylamine in detail. Their interpretation of 4-amino-1-naphthalene arsonic acid as the final product has been corrected to 1-amino-2-naphthalene arsonic acid by Brown and Hamilton.[4] These workers corroborated the findings of Boon and Ogilvie that heating of alpha-naphthylamine hydrogen arsenate with excess amine gives better yields of the rearrangement arsonic acid products than can be obtained from alpha-naphthylamine and arsenic acid directly.

Beta naphthylamine treated with arsenic acid in an attempted Béchamp repeatedly gave exclusively tar. Therefore, beta naphthylamine hydrogen arsenate has been synthesized in order to test the possibility of effecting its rearrangement by heat. The formation of this compound is somewhat more difficult than that of the alpha isomer, but the fact that it does form is indicative that a rearrangement may be effected. No arsonic acids have been obtained in several rearrangements which have been attempted.

Preparation of beta naphthylamine hydrogen arsenate: Arsenic acid (14.2 g. or 0.1 mol of H_3AsO_4) was dissolved in 360 ml. of boiling water. To the boiling arsenic acid solution was added in small portions, 0.1 mol of very finely pulverized beta naphthylamine (14.3 g.). The addition required a period of about two and one-half hours. Solution of the amine was quite incomplete at this point. Further solution of the amine was accomplished by the addition of 0.05 mol of arsenic acid (7.1 g.) and continuation of boiling for one-half hour. Total volume of liquid was maintained constant by additions of hot water as needed. The boiling solution was filtered. The precipitate (A) was reserved. The filtrate was cooled to 10° C. and the deposited precipitate (B) collected. Precipitate (A) was resuspended in the filtrate and heated at the boiling point for one-half hour. The suspension was filtered and the filtrate cooled to about 10° C. and filtered again. The precipitate from this second filtration was combined with precipitate B and recrystallized three times, from boiling water, and dried at 110° C.

Yield, 17.4 g. (61 percent of the theoretical based on the amine.)

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2. Analysed by method of Cislak and Hamilton, J. Am. Chem. Soc., 52, 638 (1930).
3. Boon and Ogilvie, Pharm. J., 101, (series 4, v. 47) 129-30 (1918).
4. H. P. Brown, and C. S. Hamilton, J. Am. Chem. Soc. 56, 151-3 (1934).

Analysis[2]: 26.26 percent and 26.30 percent arsenic. Theoretical arsenic content is 26.30 percent arsenic.

The product melts at 196° C. It is decomposed by aqueous alkali liberating beta naphthylamine in the cold.

Heated with an excess of beta naphthylamine, the hydrogen arsenate gave considerable oxidation products and decomposition material, but no substances which would give a qualitative test for the arsonic group with hypophosphorous acid.

SUMMARY

1. The preparation of beta naphthyl arsonic acid from beta naphthylamine by the Bart reaction is described and the compound obtained does not melt below 300° C., in contrast to the melting point of 155° C. reported by Michaelis. The corresponding arseno compound melts at 244° C.

2. A preparation of beta naphthylamine hydrogen arsenate is described. The compound melts at 196° C.

2. Analysed by method of Cislak and Hamilton, J. Am. Chem. Soc., 52, 638 (1930).

The Electrodeposition of Some Metals From Solutions of Their Sulfamates

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The present investigation was suggested by a recent review by Cupery (*1*) of the properties and the uses of sulfamic acid and its derivatives. This review mentioned several metallic sulfamates which have been prepared, and, among the other properties, listed the exceptionally high solubility of these sulfamates. Because of this property and the fact that these salts form stable aqueous solutions, the possibility arose of their use for electroplating. Some of the salts have been known for sixty years (*2*), but no record has been given of their use for electrodeposition of metals.

In this study, the character of the deposit from four sulfamates, copper, cadmium, zinc and nickel, was investigated under different current densities, at different temperatures, and at different concentrations. The quality of the cathode deposits was studied.

The salts were prepared either from the hydroxide or the carbonate of the metals by reaction with sulfamic acid. The acid used in these experiments, supplied by courtesy of the Experimental Station of E. I. du Pont de Nemours & Company, was of commercial grade prepared by sulfolysis of urea and had a maximum sulfate content of 0.5 percent. In its purification, the method of Butler, Smith, and Audrieth (*3*) was slightly modified. The acid was fractionally crystallized from hot water, the first crystals being discarded so that no urea might contaminate the purified acid. The sulfamate of nickel was prepared from precipitated nickel hydroxide, while those of copper, cadmium, and zinc were prepared from their respective carbonates. In preparing the salts, an excess of acid was avoided. When tested with lead salts, these showed only traces of sulfates. The lead salt was used in these tests, since there is possibility that sulfamates inhibit the precipitation of barium sulfate. The salts were recrystallized, filtered, and dried in a desiccator before making up the electroplating bath.

Stock solutions were made 0.5 molar for each salt and the required dilutions were made from these. The only exception was the preparation of a molar solution of copper sulfamate.

Observations were made in greatest detail on copper sulfamate. Current efficiency was calculated for different current densities, the calculation being based on the area of one side of the cathode. The solutions were contained in 100 ml. beakers with the electrodes arranged in series and connected in series with a copper coulometer, which was used as a standard of current measurement. Both anodes and cathodes were of electrolytic copper, thoroughly cleaned before each plating. The cathodes were washed and dried after each deposit. Electrodes were 2.5 by 2.5 cm. in size. The current was controlled by a variable resistance.

Copper plating baths were: (A) 0.5 M copper sulfamate; (B) 0.5 M copper sulfamate with 0.03 M sulfamic acid; (C) 0.5 M copper sulfamate with 0.3 M

sulfamic acid; (D) 0.5 M copper sulfamate with 5 percent ethyl alcohol. The acid solutions gave a rather high hydrogen ion concentration since sulfamic acid is highly ionized (*1*), especially in dilute solution. Various current densities were attempted with special study of those that give satisfactory copper deposits. Current efficiency is listed in Table I for the four solutions just described, the values being averages of multiple trials.

TABLE I.—Percent current efficiency for copper sulfamate

SOLUTION.	Current density in amp.-dm.^{2} t = 23°C.								
	0.1	1.5	2.0	2.5	3.25	4.0	4.7	5.0	10
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
A........	53	87	95	98	98	99	99	96	....
B........	....	89	94	96	100	100	100	97	....
C........	....	89	97	97	98	100	99	97	....
D........	....	92	91	100	108	101	104	99	85

From solution A, the deposit at 0.1 amp./dm^2. was uneven and crystalline. From 1.5 to 5.0 amp./dm^2., the deposit was firm, smooth, lustrous, and very coherent, but at 5.0 amp. the product became crystalline and lacked firmness at the edge. At 10 amp./dm^2., a thick, dark, powdery deposit occurred. From both solutions B and C, lustrous, and coherent deposits were obtained up to 5 amp./dm^2., at which current density the deposit became rough, but was still coherent and could not be stripped off. Solution D gave a fine smooth deposit even at 5 amp./dm^2., but a powdery deposit at 10 amp./dm^2. Thus solutions A, B, and C showed an increase of current efficiency up to 4.0 or 4.7 amp./dm^2., and thereafter a consistent decrease in efficiency. At 10 amp. the deposit was so loose that part of it fell off during deposition. The results from solution D were erratic and often showed over 100 percent efficiency calculated from the copper coulometer. The explanation of these results from the solution containing alcohol has not yet been made.

Since 4.7 amp./dm^2. was the limit of even deposit from solution A at 23° C., the effect of temperature was investigated, using a current density of 4.7 amp./dm^2. The quality of deposit was improved by raising the temperature up to 73° C, the highest temperature studied. The deposits above 23° C. were firm, even, lustrous, and coherent. Current efficiency decreased with rise of temperature as is shown by Table II.

TABLE II.—Current efficiency at different temperatures

SOLUTION.	Temperatures, centigrade.					
	23°	33°	43°	53°	63°	73°
	Percent.	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*
A....................	98.7	98.1	96.1	92.5	91.5	82.0

The effect of different concentrations was investigated for copper sulfamate at a current density of 2 amp./dm^2. and a temperature of 23° C. A molar solution gave a rough, loose, crystalline deposit; 0.5 and 0.25 M solutions a fine, smooth, coherent deposit; and a 0.05 M solution a loose, powdery, dark deposit.

Both platinum and cadmium anodes were used in the cadmium sulfamate with different metals as cathodes. With copper cathodes and a platinum anode, firm, even, smooth, deposits of cadmium were obtained which were adherent and took a high polish. The deposit became crystalline at a current of 4.5 amp./dm^2. At lower densities, a current efficiency as high as 98 percent was observed. Evolution of hydrogen tended to cause pitting on stationary electrodes. Cadmium anodes produced added hydrogen evolution, with only loose metal deposits. Adherent films of cadmium were plated out of weakly acid solution of 0.5 M cadmium sulfamate at 23° C. on lead, tin, and nickel cathodes as well as on copper. Very firm, smooth, adherent cadmium deposits were also made on clean iron cathodes. On copper, firmest and smoothest deposits of cadmium were obtained at 23° C. A rise of temperature up to 73° C. made deposits increasingly rough with rise in temperature.

Zinc sulfamate gave smooth, gray, firm deposits on copper cathodes when a platinum anode was used at a current density of 3 amp./dm^2. This deposit did not peel and could be polished. Satisfactory deposits were also made on zinc, nickel, and tin. When a zinc anode was employed a rough, black deposit was obtained. Increase of temperature up to 63° C. gave a smooth firm coating, although the color was darker than at lower temperatures. Above 63° C., zinc crystals formed at the edges of the cathodes. Current efficiency was not calculated for the zinc deposits.

Nickel sulfamate did not give a lustrous, shiny film on either copper or nickel, at any current density, temperature, or concentration investigated. Only a dark, nonadherent nickel coating was obtained.

In summary, satisfactory deposits of copper could be produced electrolytically from copper sulfamate over a wide range of current densities and temperatures. Zinc and cadmium sulfamates also were satisfactory for electroplating baths. Nickel sulfamate did not give satisfactory plate.

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Animal Life in Synthetic Mixtures of Nitrogen and Oxygen Under Different Conditions of Relative Humidity [1]

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In previous papers (2, 3, 4) it was shown that small animals (white mice) could not live indefinitely in a synthetic mixture of 21 percent oxygen and 79 percent nitrogen. The present study was to continue the experiments that were made here some years ago, especially to see if animals could live in the absence of rare gases.

Our comfort during cold weather does not depend alone upon being warm enough. It depends also upon the air we breathe. The temperature, moisture, air motion and cleanliness of the air itself are all contributing factors to be considered in relation to their effects upon personal comfort, particularly during the winter season. In Bulletin No. 75, "Weather and Health," National Research Council, issued by the U. S. Department of Agriculture, the following statement is made: "There is little doubt but that in most dwellings during the heating season the air is drier than is best for health and comfort. The relative humidity is too low. A room in which the air is properly humidified will be more comfortable at a lower temperature than one in which the moisture content is too low."

In dry air, plants and flowers wither quickly. Woodwork gives up its moisture and the furniture has a tendency to come apart. Windows and doors shrink. The floors creak and the piano loses its tone. If "air conditioning" is important for these material things, how much more should it be important for the health of a person in the home and the office.

Dr. Ellsworth Huntington, climatologist, of Yale University, in "Civilization and Climate," 3d edition, says: "Out-of-door winter air is moist enough, but when heated it becomes so dry that it has a devastating effect on the mucous membranes. Whenever houses are heated the evil effects of dryness are only too apparent. Air moisture is as important to our health as air temperature."

Natural air contains 21 percent oxygen, 78 percent nitrogen, and 1 percent mixture of argon, neon, krypton, xenon, helium, and carbon dioxide. About ten years ago synthetic mixtures of 21 percent oxygen and 79 percent nitrogen by volume were prepared, leaving out the rare gases. Blank tests with ordinary atmospheres were under simultaneous observation. White mice were used as experimental subjects. Without the rare gases and carbon dioxide included with the regular amount of oxygen and nitrogen as are present in the atmosphere, life would not exist over three weeks. From these results the rare gases seem to be necessary for life.

Recently this work has been repeated with many experiments, mainly by leaving out the rare gases and varying the humidity. White mice were placed in a gallon jar, uncooked oatmeal was used for feed and water was given them

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1. This paper was completed with the grant given by the Kansas Academy of Science, 1937, from a portion of the A.A.A.S. fund.

in such a way that it would not get into their feed and nest. The mixture of gas was made and dried before entering the jar. It was a constant flow into and out of the jar. The gas was dried by passing through concentrated C. P. sufuric acid, calcium chloride towers and soda lime towers. In the jar there were also soda lime and calcium chloride. The mouse was changed once a week into a clean sterilized jar, which required but a few seconds. The humidity was measured by a Hampton Humidiguide in and outside of the jar, and sometimes with a wet and dry thermometer. By these methods the humidity could not be measured with a high degree of accuracy, but it could be determined approximately.

Medically pure oxygen from the Puritan Compressed Gas Company, Kansas City, was used; and nitrogen as pure as possible was obtained from the Matheson Company, East Rutherford, N. J. A synthetic mixture of 21 percent oxygen and 79 percent nitrogen gave the following results:

March, 1937.	Temp. deg. F.	Inside humidity.	Outside humidity.	Bubbles of gas per min.	Respiration per min.
6	70	40	20	150	200
7	67	70	29	170	310
8	67	80	28	155	200
9	73	80	18	160	278
10	71	80	19	155	240
11	74	80	19	160	280
12	74	80	19	160	180
13	73	80	19	160	200
14	72	80	18	155	170
15	68	80	19	155	302
16	67	80	18	155	280
17	72	80	18	155	205
18	72	80	19	150	160
19	85	80	18	160	175
20	61	80	18	170	115
21	68	80	18	160	120
22	69	80	19	155	180
23	70	80	20	160	115
24	70	80	20	150	140
25	76	80	19	155	88
26	Mouse dead;	quite wet.			

It will be noted that the inside humidity was usually 80, but since the maximum humidiguide read 80, no doubt the true humidity was higher. With similar experiments when the wet and dry bulb thermometers were used the humidity read from 90 to 95.

In this experiment, as with a number of others under control for high humidity, we did not endeavor to keep the air dry. The purpose of the experiments with high humidity was to see how long the animals would live.

Under similar conditions an experiment was run from January 25, 1938, to February 9, when the mouse died in the presence of very high humidity. With very high humidity and the 21 percent oxygen and 79 percent nitrogen the mice would usually die from a few days to three weeks. When a low humidity was used they would live longer; in two cases seven weeks and the mice were living. By low humidity is meant from 20 to 30 percent.

Corresponding experiments were run with natural air with high and low humidity. As a general rule, with a very high humidity in normal air the

mice would die as they did with oxygen and nitrogen, but in longer periods of time, and never with low humidity, as they usually did with the oxygen and nitrogen.

The mice would drink practically no water in the presence of highly humid air. Under these conditions they always appeared to droop, to lose vigor, to become dull and to lose weight. After dissecting, such mice were found to be quite inflamed and the blood quite black and the lungs, liver, kidneys, and heart, dark in color.

We are continuing these experiments to see what further might be learned, especially the effects of the rare gases and synthetic mixtures of oxygen and nitrogen.

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Surface Structure and Paint Adhesion Mechanisms of Softwoods [1]

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The nature of wood surfaces has become definitely recognized as an integral part of the serviceabilities of paints and painted surfaces. Even when good paints are well applied, it is found that some woods exhibit better weathering surfaces than others. The Forest Products Laboratory has made a definite contribution in this field (*1*) and undoubtedly future investigations by this group of experts and coöperative enterprises among the technical men of the paint industry will reveal much information concerning the mechanisms of paint adhesions and integrities of weathered films.

CHEMICAL CONSTITUTION

Intermingled and superstructurally combined, the cellulose unit, $(C_6H_{10}O_5)_n$, constitutes most of the woody or fibrous portion of plants. In woody tissue, the layers of cellulose fibers are cemented together by a material called lignin. These substances, which are called the wood substance, are very much the same in all woods. Wood materials are hygroscopic, swelling substances, whose water content is dependent upon the humidity of the surrounding air. At saturation, wood roughly contains thirty percent by weight of water. Green wood always contains more water than is required to saturate it. In addition to these wood substances, wood materials contain certain extractives whose composition and quantity vary considerably with its source. These materials are classified as organic soluble and water soluble constituents. The former involves turpentines and resinous extractives while the latter includes tannins, organic acids like formic, acetic, etc.

PHYSICAL STRUCTURE

Lumber is utilized from many different species of trees and upon studying the structure of the wood, it has been found that there is a great variance between trees of different species and even among trees of the same species. For the purpose of understanding the subject, woods have been classified as softwoods or those cut from coniferous or needle or scale leaves, and hardwoods as those from broad-leaved trees. This does not separate the woods according to the actual hardness, as the hardest of the softwoods may be considerably harder than the softest of the hardwoods. This paper considers only the softwoods because exterior lumber of buildings is almost exclusively of that kind; however, occasional reference is made to hardwoods for comparative purpose.

Softwoods consist of conical cellular structures called tracheids. These are estimated to be 2 to 4 mm. long by less than 0.03 mm. wide. Hardwoods have pores (tracheae) some of which are of large size and arranged roughly in a

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1. Contribution No. 235, Department of Chemistry, Kansas State College. Photographs: Courtesy of Forest Products Laboratory.

circle. Such are called ring porous, while others have small pores which are difficult to see, even under a microscope. The latter are called diffuse porous. In addition to these pores and tracheids, which run longitudinally, there are very small cells running radially in the trunk. They occur in thin sheets radiating from the pith to the bark. These rays are called pith rays or medullary rays. They are best observed on a quarter section and it is these rays that give to oak and sycamore their beautiful flaky appearance. The drawings in figures 1 and 2 represent cell structures of the minute blocks of soft and hardwood.

When the tree renews growth in the spring, the new cells are large and thin walled. As the growing season progresses, there are formed smaller and thicker walled cells, until in the late summer the growth is very much more dense than in spring. Sometimes this change is gradual, as in white pines and firs, or it may be abrupt as in yellow pines. This change produces a very visible ring or increment by which the age of the tree may be determined. Tropical trees have been found to contain no rings, as there is no cycle of inactivity. Figure 3 shows a cross-sectional area of a tree trunk.

The series of rough concentric rings, resulting from this oriented fibrous structure, bring about the surface grain effects in the cut lumber. Surfaces which are cut at right angles to the axis of the log, cut through the fibers transversely and are known as end-grain surfaces. Only the ends of boards present end-grain surfaces. If the principal surfaces of a board lie in planes that run approximately radially to the annual rings, they are edge-grain surfaces and the board is an edge-grain board. If the principal surfaces of the board lie in the planes approximately tangent to the annual rings, they are flat-grain surfaces and the board is a flat-grain board. Lumber cut from relatively small trees consists predominantly of flat-grain boards. In cutting lumber from large trees that yield a high proportion of clear material, it is possible to separate the boards into edge, mixed and flat-grain. In flat-grain, the side adjacent to the bark is known as the bark side.

PAINT ADHESION

The particular types of adhesion which are of interest in the case of paints have been characterized (*3*) as first, mechanical adhesion, which is dependent on penetration of the paint into the surface, and second, the sort of adhesion which is due to molecular attraction and is governed by molecular structure. To the latter class belongs the adhesion mechanisms on smooth, nonporous surfaces such as those of polished metals, glass, vitreous enamels, etc., where no mechanical adhesion can act.

Between the medullaries and tracheids have been found minute openings of the order of 0.00002 mm. Air and liquids may pass, but the particles of paint pigments cannot. The particles of paint have been found to fill only the cut cells on the surface while the oils of paint which penetrate to some depth occupy the openings of the cells as free liquids and do not affect the dimensions. Figures 4 and 5 show coatings of paint on wood surfaces.

An increased number of rings of summer wood results in a greater strength of the wood, a better oil penetration and a less durable film of paint, as found by Forest Products Laboratory. It is found that disintegration of a film starts in a first-class board over the bands of summer wood. This is rather in con-

tradiction of the fact that the oil is found to penetrate into the summer wood more deeply than in the spring wood. Penetration has been found to be much greater in longitudinal grain than in edge or slash grain. Sapwood is more easily penetrated than heartwood. Penetration in the pith or medullary rays has been found to take place to a very slight extent.

Penetration has been found to depend a great deal upon conditions at the time of paint application and in this respect, the moisture content is especially important. The method of seasoning plays an important part in penetration. It has been found sometimes that, upon curing the wood, the cell walls seemingly collapse and upon doing so, apparently rupture the cell walls, as penetration in cured wood is much faster and proceeds to a greater extent than in green wood.

There are two theories of penetration (*2*): first, that oil passes through resin ducts of coniferous woods, and, second, that the oil penetrates in a capillary action through the cell walls. The first may be discounted in that some woods containing very pronounced resin ducts are very resistant to oil pentration as found by technical men in the U. S. Department of Agriculture.

The second theory finds basis for argument. The pores or vessels which tend to serve as passages for sap in the living tree may serve as oil passages in cured wood. The pores of wood are of two types: (A) Open pores in a ring porous wood such as red oak permit penetration of the oil to a distance of several feet. In diffuse porous, the same situation is at hand; although the pores are smaller, they are more numerous. (B) Pores closed by gum or "tyloses," or only partially closed, make penetration difficult or impossible. Tyloses are bladderlike substances which may completely block off the cell passages of the wood.

Very little data is available upon this portion of paint study and there is a great need for further information on the mechanism of the passage of liquids through wood. Such can be obtained by purely structural microscopic studies. While oil has been found to penetrate rather deeply in porous woods, the particles of pigment, while they may be of colloidal size, are yet too large to penetrate through the cell walls by capillaric action.

CONCLUSION

The ideal coating should give adequate protection against weathering and the surface should wear evenly over summer wood and spring wood alike, being firmly attached to all parts of the wood. Localized disintegrations should be unknown. Obviously, the problem is one of securing firmer and more permanent adhesion between coatings and wood and its solution is a direct challenge to the application of the chemical and physical laws.

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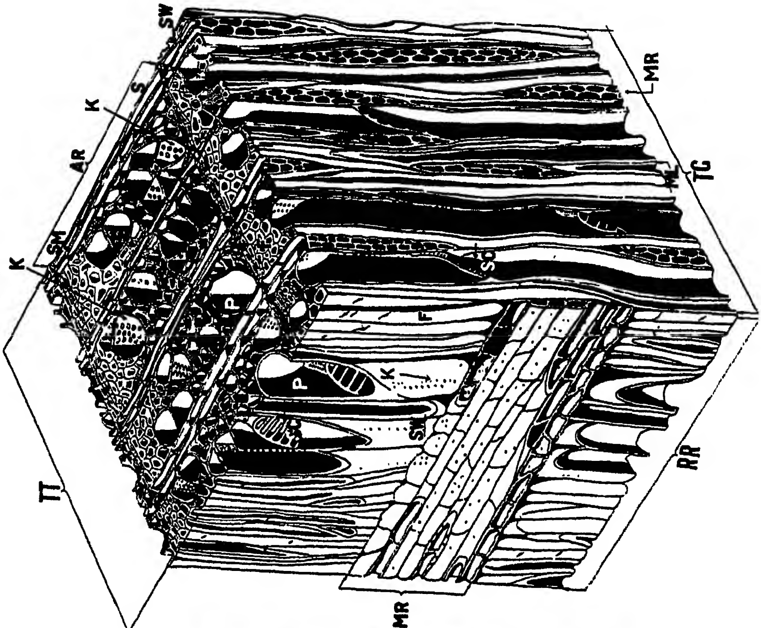
EXPLANATION OF FIGURES

FIG. 1. Microscopic structure of a softwood. TT is transverse (end-grain), TG tangential (flat-grain or plain-sawed), RR radial (edge-grain or quarter-sawed), AR annual growth ring, S springwood, SM summerwood, MR medullary ray, ML middle lamella (lignin) which cements the cellulosic cell walls, SW together, TR tracheid, MRT medullary ray traceheid, FMR fusiform medullary ray containing horizontal resin passage HRD, VRD vertical resin passage, BP bordered pit, SP simple pit. (Forest Service M 724 F).

FIG. 2. Microscopic structure of a hardwood. TT is transverse (end-grain), TG tangential (flat-grain or plain-sawed), RR radial (edge-grain or quarter-sawed), AR annual growth ring, S springwood, SM summerwood, MR medullary ray, ML middle lamella (lignin) which cements the cellulosic cell walls, SW together, F fiber, P pore or vessel, SC open grid at spliced joint in a large pore, K pits. (Forest Service M 725 F.)

FIGURES 1 AND 2

2



1

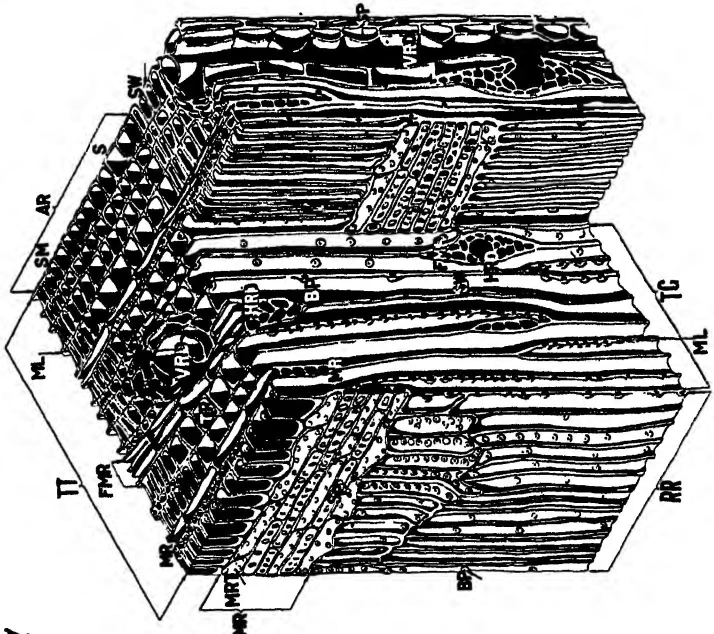


FIGURE 3

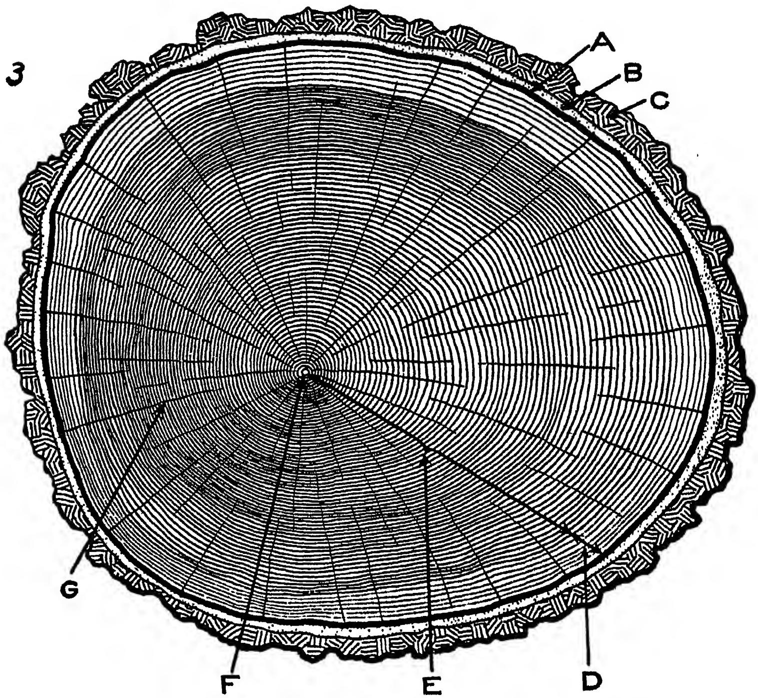
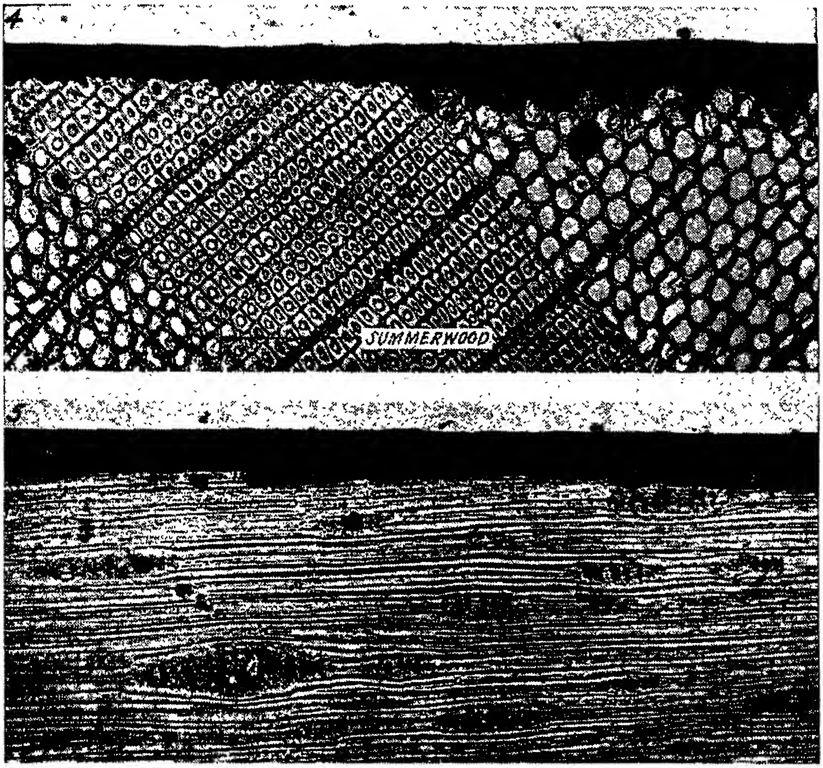


FIG. 3. Cross section of a tree trunk. A, cambium layer (microscopic) is inside of inner bark and forms wood and bark cells. B, inner bark is moist and soft. Carries prepared food from leaves to all growing parts of the tree. C, outer bark or corky layer is composed of dry, dead tissue. Gives general protection against external injuries. D, sapwood is the light-colored wood beneath the bark. Carries sap from roots to leaves. E, heartwood (inactive) is formed by a gradual change in the sapwood. Gives the tree strength. F, pith is the soft tissue about which the first wood growth takes place in the newly formed twigs. G, wood rays connect the various layers from pith to bark for storage and transference of food. (Forest Service ZM 22596 F).

FIGURES 4 AND 5



FIGS. 4, 5. Paint coatings on southern yellow pine, photomicrographs by transmitted light. Figure 4 is a transverse (end-grain) section and figure 5 is a longitudinal section. The paint appears black because it is opaque. The paint penetrates into the cavities of only those tracheids that open into the painted surface because the pigment particles are far too large to pass from one cavity to another. Linseed oil from the paint, however, penetrates far deeper into the wood. This oil does not show in the photographs because it is transparent. (Forest Service M 24953 F).

Phosphorus Absorption by Wheat as Influenced by Applications of Lime and Phosphorus[1]

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The literature on the subject of phosphorus availability to plants has increased greatly during recent years. The subject is complex, and no paper or series of papers will cover the subject exhaustively. The purpose of this paper is to show the relation between phosphorus solubility (*1*) (*2*) and absorption of phosphorus by plants grown on soil variously treated with lime and phosphate.

In working with a hydrogen saturated Cherokee loam, Perkins, Benne and King (*2*) found that $CaCO_3$ applications sufficient to raise the pH value of the soil from 3.36 to 6.75 decreased the P_2O_5 solubility of the native phosphate from 0.20 to 0.14 p.p.m. $CaCO_3$ additions to a portion of the same soil saturated with calcium raised the pH from 5.17 to 7.41 and decreased the soluble P_2O_5 from 0.21 to 0.17 p.p.m. Benne, Perkins and King (*1*), in working with additions of $CaCO_3$ to aqueous solutions containing phosphoric acid (H_3PO_4), found that lime decreased the soluble P_2O_5 from 727 p.p.m. to 59 p.p.m. while the pH was raised from 4.88 to 7.01. When an aqueous phosphorus solution similar to the preceding one was added to a calcium saturated loam and increasing amounts of $CaCO_3$ were added, the soluble P_2O_5 decreased from 394 p.p.m. to 221 p.p.m., while the pH value changed from 5.02 to 6.99. When CaO was substituted for $CaCO_3$ the soluble P_2O_5 decreased from 394 p.p.m. to less than 0.01 p.p.m., while the pH was raised from 5.02 to 7.46.

These data all indicate that when the pH value of a system was raised by lime the solubility of phosphorus decreased. This was true whether the system was a solution or a soil suspension and, in the case of the latter, whether the phosphate was native or applied. The carbonate was less effective in precipitating phosphorus than the oxide.

In southeastern Kansas many soils are acidic in nature and deficient in phosphorus, and the question naturally arises as to what is the best system to employ in applying lime and phosphate. The plants need lime and phosphate, but laboratory studies (*1*) (*2*) indicate that the addition of lime may under certain conditions decrease the solubility if not the availability of phosphate. Accordingly, a series of pots was set up in the greenhouse to measure the phosphorus absorbed by plants when different amounts of lime and phosphate were applied to the soil. Results obtained by Benne, Perkins, and King (*1*) indicated that the order of application of lime and phosphate affected the solubility of the phosphate. Accordingly, two series of pots were prepared. One set received the lime four weeks before the phosphate, and the other series received the phosphate four weeks before the lime. The results obtained in the two series checked and indicated that no difference resulted

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1. Coöperative investigation between the departments of Chemistry and Agronomy. Contribution No. 242, Department of Chemistry, and No. 292, Department of Agronomy.

in this soil by virtue of the order of application. The results of one series only are tabulated and results reported as duplicate averages while in reality quadruplicate checks were obtained.

EXPERIMENTAL

A Cherokee silt loam known to be deficient in phosphorus was selected as the test soil. Sixty-four portions (1,750 grams each) of soil were placed in 2-quart glazed earthenware jars and the soil treatments were made in duplicate. $CaCO_3$ was applied at rates of 1, 2.5 and 5 tons per acre, (i. e. per 2,000,000 ibs. of soil) and calcium hydrogen phosphate $CaH_4(PO_4)_2$ applied at rates of 30, 75, and 150 pounds per acre. Pots were thus provided which were treated with lime but no phosphate, phosphate but no lime, both lime and phosphate, and neither lime nor phosphate. The results for the first 32 pots only are reported and a schematic outline of the treatments is given in Table I. The experimental results obtained are listed in Table II. The pH values listed were obtained by the use of a quinhydrone electrode. The amount of P_2O_5 in the plants was determined by the volumetric method as given in the *Methods of Analyses—A. O. A. C.* The soil was maintained at a moisture content equivalent to 80 percent of its water holding capacity. The pots were weighed three times per week and sufficient water added to return the moisture level to 80 percent. The grams of water lost for the duration of the experiment were calculated and then the amount of water lost per gram of dry matter produced and per milligram of P_2O_5 absorbed calculated.

TABLE I.—Arrangement of greenhouse experiment: pot numbers, lime and phosphate applications*

	Pot numbers.				$CaH_4(PO_4)_2$ pounds per acre.
	1 17	2 18	3 19	4 20	0
	5 21	6 22	7 23	8 24	30
	9 25	10 26	11 27	12 28	75
	13 29	14 30	15 31	16 32	150
$CaCO_3$ Tons per acre.....	0	1	2.5	5	

*Example: Pots numbered 6 and 22 received 80 pounds of $CaH_4(PO_4)_2$ and one ton of $CaCO_3$ per 2,000,000 pounds of soil.

TABLE II.—Experimental results

Pot numbers

1 / 17	2 / 18	3 / 19	4 / 20
5 / 21	6 / 22	7 / 23	8 / 24
9 / 25	10 / 26	11 / 27	12 / 28
13 / 29	14 / 30	15 / 31	16 / 32

pH values when planted,[1] average of 2 pots

5.62	6.66	7.70	7.92
5.87	*6.94	7.80	6.91
*5.73	6.95	7.73	7.97
*5.66	*6.77	7.77	7.93

* Single determinations.

Green weight grams,[1] average

6.2	3.5	7.5	7.2
6.6	5.2	7.8	8.8
7.3	6.1	8.5	10.2
7.9	6.2	8.5	10.5

P_2O_5 absorbed, mg.,[1] average

5.0	3.2	6.5	5.6
5.5	4.1	8.2	8.0
5.3	4.6	7.8	10.5
6.8	5.1	7.1	8.0

100 grams water lost[1] per gram dry matter produced

15	21	10	11
10	12	11	11
10	12	11	11
9	11	9	9

Grams water lost per[1] mg. P_2O_5 absorbed

380	500	290	300
310	370	230	240
320	350	230	190
260	310	240	240

DISCUSSION

In Table III are given average results, that is, in the first case, the results for pots numbered 1, 17, 2, 18, 3, 19, 4, and 20 are averaged and represent results obtained where no phosphate was applied. In the second case, the results for pots numbered 1, 17, 5, 21, 9, 25, 13, and 29 are averaged and represent results obtained where no lime was applied.

It will be noted that in every case where sufficient lime was applied to raise the pH value of the soil from approximately 5.73 to approximately 6.83, regardless of the amount of phosphate applied, the amount of crop produced decreased, phosphorus absorbed decreased, amount of water consumed per 100 grams of dry material increased and grams of water consumed per mg. P_2O_5 absorbed increased. Every observation indicates that application of lime sufficient to produce this approximate pH value (6.83) produced an unfavorable result. However, when heavier applications of lime were made which raised the pH value to approximately 7.75 and 7.93, plant response, phosphorus utilization and water consumed were more favorable than with no lime, or light lime applications. Green weight of crop increased, mg. P_2O_5 absorbed increased, while grams of water per gram of dry crop and mg. of P_2O_5 absorbed per gram of dry crop decreased with the heavier lime applications. In brief, a light application of lime resulted in less crop, less phosphorus absorption and poorer economy of water use than no lime, but heavier applications made every item more favorable. On the other hand,

1. Each value given corresponds to the pot numbers shown in similar position in the upper left section of the table.

regardless of pH and lime application, progressively heavier applications of phosphate increased plant growth and phosphorus absorption while water consumption per 100 grams of dry crop produced, and per mg. of P_2O_5 absorbed, decreased.

TABLE III.—Average results of increasing $CaH_4(PO_4)_2$ applications, all lime treatments averaged*

$CaH_4(PO_4)_2$ per 2,000,000 pounds of soil.	Green weight crop.	P_2O_5 absorbed.	Water lost per g. dry matter produced.	Water lost per mg. P_2O_5 absorbed.
Pounds.	Gm.	Mg.	100 gm.	Gm.
0	6.1	5.1	14.3	368
30	7.1	6.5	10.8	288
75	8.0	7.1	11.0	273
150	8.3	6.8	9.5	203

* Each figure is the average from 8 pots with different $CaCO_3$ applications.

TABLE IIIA. Average results of increasing $CaCO_3$ applications, all phosphate treatments averaged*

$CaCO_3$ per 2,000,000 pounds of soil.	Green weight crop.	P_2O_5 absorbed.	Water lost per g. dry matter produced.	Water lost per mg. P_2O_5 absorbed.
Tons.	Gm.	Mg.	100 gm.	Gm.
0	7.0	5.7	11.0	318
1	5.3	4.3	14.0	383
2.5	8.1	7.4	10.3	220
5	9.2	8.0	10.5	221

* Each figure is the average from 8 pots with different $CaH_4(PO_4)_2$ applications.

CONCLUSIONS

On a phosphorus deficient acid soil—

1. Progressively heavier phosphate applications up to 150 pounds of monocalcium phosphate per 2,000,000 pounds of soil gave increasingly marked plant response and phosphorus absorption.

2. Small applications of lime resulted in decreased plant growth, decreased phosphorus absorption and less economical water utilization as compared to unlimed soil. Larger applications reversed this behavior.

3. Since this work was carried out on one soil only, work of both more intensive and extensive nature is desirable.

4. Phosphorus absorption by plants in this experiment is in accord with phosphorus solubility curves published by Perkins, Benne, and King, up to a pH value of approximately 7.00.

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The Lime Content of Rocks of the Upper Cretaceous System of Osborne County, Kansas [1]

HERMAN SEARCH and ROY RANKIN, F. H. K. S. C., Hays, Kan.

The greater part of Osborne county, Kansas, is covered by rocks of the Upper Cretaceous age. Only a relatively small part of it is covered by Tertiary and Quaternary sediments. The Niobrara formation, which is the highest and youngest part of the Cretaceous, is subdivided in Kansas into an upper member, the Smoky Hill chalk, and a lower, the Fort Hays limestone. The Fort Hays limestone is much the more prominent member of the Niobrara formation in Osborne county, and differs from the overlying Smoky Hill chalk largely in its proportion of massive chalk to chalky shale.

Immediately below the Fort Hays limestone is the Carlile shale, which is divided into two members, the Blue Hill shale above and the Fairport shale below. The essential difference between the two is the absence of calcareous material in the former, whereas the Fairport is highly calcareous.

The Greenhorn formation is unimportant in Osborne county, appearing only in river bottoms at the eastern and southern edges of the county.

In making this study, the writer was concerned chiefly with the chemistry of the rocks rather than with their geological formation. He did not attempt to make a complete analysis of the rocks, but limited his investigation in order to determine certain facts concerning their lime content. He attempted to determine the consistency of the percentage of lime in a given member in various parts of the county and also of different beds of a given member in the same locality. He also investigated the possibility of the existence of limestone of a percentage sufficiently high to be used for cattle feeding and for the manufacture of lime.

The fifty-four rock samples used in this investigation were obtained through personal visits to surface outcroppings of the strata in various localities. Whenever layers of different rock formations were noticed in the same outcropping, a sample of each was taken. A geological map of Osborne county, published by the State Geological Survey, was used as a guide in determining the location of the various strata. The writer would drive his car along a section line until he observed an outcropping of a desired stratum. By carefully checking his speedometer, he was able to get the exact location of the sample. The sample was taken from the outcropping by use of a hard steel chisel and hammer, care being taken to cut away the weathered surface of each rock so that a clean, fresh, unaltered sample was obtained. Each sample was placed in a glass jar, properly labeled, and taken to the laboratory.

The rock was then submitted to an analysis, using the procedure as outlined by Talbot (pp. 184-198).[2] The calcium present was precipitated as calcium oxalate, which was subjected to a volumetric analysis. An approximately

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1. An abstract of a thesis presented by Herman Search, B. S., in partial fulfillment of the requirements for the degree of Master of Science, under the direction of Prof. Roy Rankin, of Fort Hays Kansas State College.

2. Talbot, Henry P. *Quantitative Chemical Analysis*, 7th ed., New York, 1931.

tenth-normal standardized solution of potassium permanganate was used as the titrating solution. From this data the writer was able to calculate the percentage of lime content in the various samples. This is shown in the accompanying table.

TABLE I.—Percentage of lime content in the various members

NIOBRARA FORMATION

Smoky Hill.		Fort Hays.			
Sample.	Percentage.	Sample.	Percentage.	Sample.	Percentage.
1	50.82	5	53.78	25	53.89
4	49.04	7	51.70	26	53.80
10	51.77	8	52.74	28	53.23
11	46.26	9	50.53	30	54.45
14	46.70	12	52.82	31	52.66
15	53.37	13	52.97	33	54.32
27	53.45	16	51.49	34	52.74
32	50.65	18	54.56	36	53.48
35	53.16	19	53.15	39	51.85
37	49.09	20	53.19	40	52.74
38	50.67	21	54.10	42	51.78
44	53.84	22	54.44	43	54.39
52	38.18	23	54.10	46	53.63
		24	55.49		
Averages...	49.77	....	....	....	53.26

TABLE I.—CONCLUDED

Carlile shale.

Blue Hill shale.		Concretions of Blue Hill shale.		Fairport chalk.		Greenhorn limestone.	
Sample.	Percentage.	Sample.	Percentage.	Sample.	Percentage.	Sample.	Percentage.
41	5.061	2	38.02	54	53.05	29	53.20
45	.252	3	30.36	....	....	47	46.45
51	1.016	6	37.03	....	....	48	55.08
53	.298	17	35.28	....	....	49	54.26
....	....	....	....	....	....	50	54.47
Averages..	1.657	....	35.17	....	53.05	....	52.69

The percentage of lime ranged from .252 for the sample of Blue Hill shale taken from sec. 5, T. 8 S., R. 12 W., to 55.49 for the sample of Fort Hays limestone obtained from sec. 10, T. 8 S., R. 15 W.

The range was not nearly so great for the samples of the same member, the high run for the Smoky Hill chalk member being 53.84 percent lime, while the low run was 38.18 percent. This member ran fairly high in lime content, ten of the thirteen samples running better than 49 percent lime.

Samples of the Fort Hays limestone ran fairly constant in regard to the

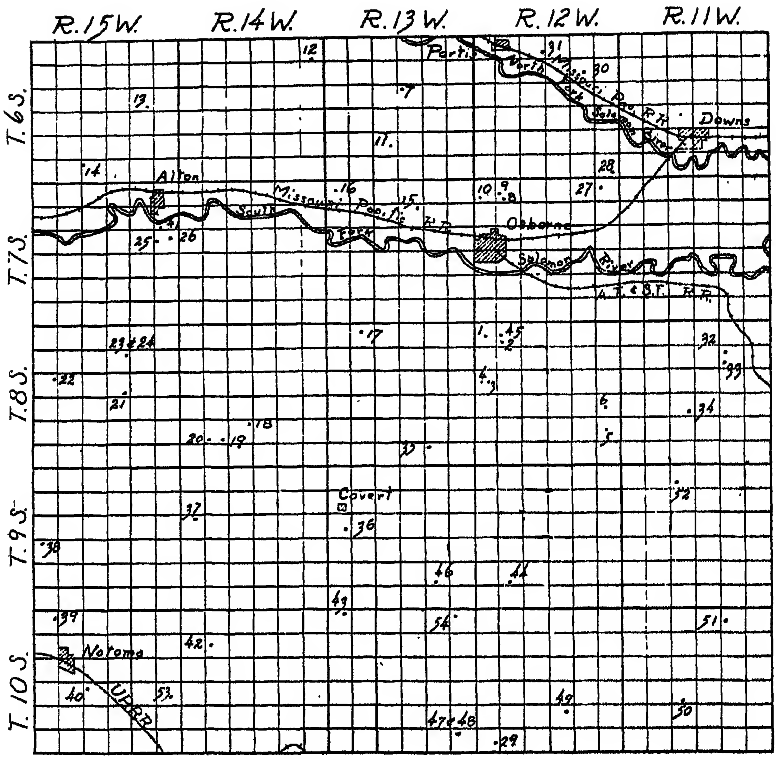
percentage of lime present, the high run being 55.49 percent while the low run was 50.53 percent, a variation of approximately 5 percent. Samples of this member from the same stratum, but in beds a few hundred feet apart, showed very little difference. For example, samples 8 and 9 from separate outcroppings about 300 feet apart in sec. 5, T. 7 S., R. 12 W., contained 52.74 percent and 50.53 percent of lime, respectively. Also, sample 23, taken from a road-cut in sec. 10, T. 8 S., R. 15 W., about three feet below the surface, had a lime content of 54.1 percent, while sample 24, taken from the same stratum, but in a bed six feet below the former sample, ran 55.49 percent lime. Each of the twenty-seven samples of this member ran better than 50 percent lime.

The Blue Hill shale member showed a comparatively wide variation in lime content among its samples, with a high run of 5.061 percent and a low run of .252 percent. However, two of the four samples were fairly constant.

The concretions of the Blue Hill shale, while not considered to be representative of that or any other stratum, ran surprisingly uniform in lime content. There was a variation of only approximately 7.5 percent between the high and the low run.

Four of the five samples taken from the Greenhorn formation ran fairly constant in the percentage of lime, the percentages ranging from 53.20 percent to 55.08 percent. Evidently, the Greenhorn of Osborne county runs fairly constant in the percentage of lime.

It is apparent that Osborne county, Kansas, has much valuable limestone suitable for the manufacture of cement and commercial lime. It also has an abundance of limestone which contains a calcium carbonate percentage sufficiently high to make it useful for agricultural lime and for cattle-feeding rations. However, since there is no near ready market for lime products, it is doubtful that this natural resource will be used industrially for many years to come.



Map of Osborne county, Kansas, showing location of the various numbered samples.

The Electrodeposition of Zinc in the Presence of Organic Addition Agents

C. H. SENTER and ROBERT TAFT, University of Kansas, Lawrence, Kan.

This paper reports a determination of the optimum conditions[1] of concentration, current density and temperature in the electrodeposition of zinc from both acid and alkaline plating baths in the presence of some twenty-five selected organic compounds. Although there have been a number of studies of addition agents for this metal, in but few instances have attempts been made to determine optimum conditions (*1*).

Our method consisted in adding a given addition agent to standard acid and alkaline baths, plating out the zinc, and comparing the form and mass of the zinc deposited with that secured from the standard baths in the absence of any such addition agents. In the preliminary trials the bath was made ½ N with the addition agent if solubility permitted, otherwise a saturated solution was prepared. Electrolysis was carried out at a current density of 1 ampere per square decimeter and at 30° C. The substances selected for study were:

Formic acid	pHydroxy-benzoic acid	pHydroxy phenylglycine
Acetic acid	Maleic acid	Phenyl glycine
Lactic acid	Barbituric acid	Ethyl carbamate
Oxalic acid	Glycollic acid	Alpha naphthol
Tartartic acid	Succinic acid	Beta naphthol
Gallic acid	Di-phenyl glycollic acid	Glycerine
Malonic acid	Anthranilic acid	Phenol
Benzoic acid	Salicylic acid	Sucrose

The compositions of standard baths used in all trials were (*2*):

Acid bath:	
Zinc sulfate	3N
Sodium sulfate	2N
Sulfuric acid	0.01N
Alkaline bath:	
Zinc oxide	1N
Sodium hydroxide	5.5N

Of the twenty-five substances examined in the preliminary trials, nine were found to produce deposits from the acid bath distinctly smoother and whiter than those obtained from the standard bath alone. Only one, however, was found in the case of the alkaline bath. These ten substances, therefore, were selected for further study.

In the experimental conditions adopted, the baths were contained in 100 c.c. beakers; zinc anodes and copper cathodes 2.5 centimeters square were placed in each bath. Electrolysis was conducted by passing a constant direct current through some eight or ten cells in series with each other; the electrolyte, in all cases studied, was never stirred. Each trial was run in

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1. By optimum conditions we mean the conditions most favorable to the production of a smooth, bright and adherent cathode deposit.

duplicate and a duplicate pair of copper coulometers was included in each series of studies. From the gain in weight of the cathodes, the current efficiency was calculated, assuming the copper coulometer to be one hundred percent efficient. The dried and weighed cathodes were examined microscopically and classified into six groups. The type of deposit in each of the six groups was described as follows:

Type of Deposit

1. Finest crystals: very smooth, even, very bright, white with a metallic luster, excellent cover on back.
2. Very fine crystals: smooth, few gas holes, bright, white-grey deposit, good cover.
3. Fine crystals: smooth, large number of gas holes, light grey, good cover.
4. Medium sized crystals: slightly rough, many gas holes, medium grey, fair cover, treeing tendency at higher current densities.
5. Medium large crystals: rough, many gas holes, medium grey, fair cover, slightly loose, trees at higher C. D.
6. Large crystals: rough, course deposit, many gas holes, dark grey, loose and porous, trees at higher C. D.

The optimum conditions, as we record them here, were determined by first varying the concentration of addition agent, maintaining the current density at 1 ampere per square decimeter and the temperature at 30°C. Once the optimum concentration of addition agent was determined, the current density was varied at this concentration to find the most suitable current density. Trials at the optimum concentration and current density were then carried out at 0°C. and 100°C. to determine the effect of variation of terperature. It is, of course, realized that in the procedure outlined here for the determination of optimum conditions, better deposits might possibly have been obtained if variations of concentration had been made at all current densities and temperatures employed. Time did not permit so extensive a study, however.

The data obtained for deposits produced in the presence of lactic acid will illustrate our procedure:

Cons. (N)	C. D.[2]	Temp.	C. E. Percent	Type
6	1	30°	60.5	4
3	1	30	76.9	3
1	1	30	89.5	4
0.5	1	30	93.9	5
0.25	1	30	94.6	5
0.1	1	30	96.3	5
3	1	30	76.9	3
3	2	30	96.3	3
3	4	30	87.5	2
3	8	30	86.5	3
3	4	100	89.7	4
3	4	30	87.5	2
3	4	0	79.2	3

2. Amperes per square decimeter.

In a similar fashion, optimum conditions for the other nine selected substances were determined. The optimum conditions are tabulated below.

Acid Baths	Conc. (N)	C. D.[3]	C. E. Percent	Temp.	Type
1. Lactic acid	3.	4	87.5	30°	2
2. Citric acid	0.25	8	99.	30	1
3. Benzoic acid	0.004	4	97.9	0	2
4. Phenol	0.09	2	100.	100	4
5. Ethyl Carbamate	0.25	4	99.9	30	2
6. Beta Naphthol	0.0007	2	100.	0	2
7. Hydroxy-phenyl glycine (p)	0.0003	4	97.2	30	2
8. Hydroxy Benzoic acid (p)	0.01	8	100.	30	2
Alkaline Bath					
9. Beta Naphthol	0.1	1	99.8	30	2

A type 4 deposit was obtained from the standard acid bath under its most favorable conditions (1 ampere per square decimeter at 30°); for the standard alkaline bath, a type 5 deposit was obtained under similar conditions.

The mechanism by which addition agents produce their effects still remains to be worked out. An examination of the character of the substances in the above list suggests, at first thought, that the formation of complex ions is quite probable. As is well known, metallic deposits from solutions containing complex metallic ions are usually smoother than deposits obtained from the simple metal ion. There are, however, several experimental lines of evidence indicating that the effect of these substances is produced in some other way than through the formation of complex ions. In the first place, zinc sulfide is precipitated as readily, and to the same apparent extent, from any of the above baths in the presence of the organic compound as it is in their absence. To be sure, the bath must be neutral and therefore the deposit of zinc sulfide is obtained from solutions under different conditions than they were actually employed during electrolysis. We have, however, determined the decomposition potentials of all the baths employed by the familiar method of Le Blanc (*3*) and have found no difference in the presence or absence of addition agent. Marked change in the concentration of simple zinc ion would have produced an appreciable difference in the decomposition potential.[4]

It will also be noted that the addition agents in the above list produce their optimum effects over a wide range of concentrations; in some cases at so low a concentration that even if complex ions were produced from all the addition agent present, but slight changes in the concentration of simple zinc ions would have resulted. Sato (*4*), too, has pointed out that compounds containing OH and NH_2, compounds which would most likely produce complex ions with zinc, are not essential constituents of effective addition agents for zinc deposition, a view which previous to Sato's work had been the prevailing conception of addition agents for this metal. It therefore appears probable that these addition agents produce their effects in other ways than by complex ion formation. As one of us has pointed out (*5*), adsorption of addition agent by

3. Amperes per square decimeter.

4. The decomposition potentials were determined by the use of a platinum anode and copper cathode. In all cases (with one exception) the decomposition potentials were found to be 3.0 volts. The single exception was the acid bath containing para hydroxy-phenylglycine, where the decomposition potential was found to be 2.2 volts.

metal many times plays an important part in determining the character of the deposited metal. Field and Weill (*6*) have specifically stated that zinc deposited in the presence of addition agents shows definite evidence of adsorption of addition agent. Although we made no analysis of the zinc deposits, several instances clearly indicating some form of occlusion of addition agent were apparent in our studies. In a few trials, for example, it was found that deposits produced from the alkaline bath in the presence of high concentration of sugar were black and rubbery and of excessive weight, as is shown by the following data obtained at a current density of 1 ampere per square decimeter at 30°C.:

Conc. of Sugar (N)	C. E. Percent	Type
2.	643.	6.
1.	137.	6.
0.25	105.	5.
0.10	105.	5.

It seems more probable, from the available evidence then, that the addition agents studied produce their effects upon the form and weight of the cathode deposits by adsorption. It should be pointed out, of course, that there is no guarantee that all addition agents produce their effects by the same mechanism.

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2. The composition of these baths, as far as metal content is concerned at least, are those suggested in Blum and Hogaboom, *Principles of Electroplating and Electroforming,* 2d edition, New York (1930), pp. 324 and 331.
3. *Zeit. Phys. Chem.*, 8, 299 (1891).
4. See reference to Sato's paper in Note 1.
5. Taft, *Trans. Electrochem. Soc.*, 63, 75 (1933).
6. *Electro-Plating*, London, 1935, p. 161.

Derivatives of 1-Imino-benzthiazole

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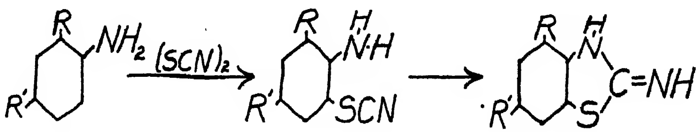
The direct thiocyanogenation of aromatic amino-compounds has attracted considerable interest during the last few years. In the procedure followed by most investigators,[1] the amine (one mole) and ammonium sulfocyanate (2 moles) were dissolved in glacial acetic acid, and bromine, or a chloramide, added. The liberated thiocyanogen substituted in the position para to the amino group or if that were occupied, in the the ortho position. These products in which the thiocyanogen substitution takes place in the ortho position were of special interest to us in that they rearrange to benzthiazoles similar to those which have previously been studied in this laboratory. The present investigation is a continuation of the work in this field done by Brewster and Dains,[2] especially concerning the applicability of the method to disubstituted amino compounds. It is well known that if only the group para to the amino group (R′) is present (see fig. 1) the thiocyanogenation occurs readily regard-

1 

less of the character of R′ (alkyl, halogen, carboxyl, nitro, etc.), but some experiments had indicated a greatly reduced degree of thiocyanogen if groups were present at both the ortho and para positions. In order to investigate the usefulness of the reaction in such cases, a series of 2-4 disubstituted anilines was prepared and the thiocyanogenation of each was studied. A typical experiment is described under the "General Procedure" and the results of other experiments are shown in Table I.

GENERAL PROCEDURE

Fourteen grams (0.1 mole) of 2-chloro-4-methyl aniline and 16 g. (0.2 mole) of ammonium sulfocyanate were dissolved in 500 cc. of glacial acetic acid and the solution cooled in an ice bath to about 10°. The solution was stirred mechanically and 16 g. (0.1 mole) of bromine dissolved in 100 cc. of glacial acetic acid was added drop by drop. About two hours were required for the addition of the bromine and the stirring was continued for another half hour in order that the reaction might be complete. Toward the end of the process some solid material separated, which consisted partly of a polymer of thiocyanogen and partly of the hydrobromide or thiocyanate of the iminobenzthiazole. The entire mixture was poured into a liter of water, to which was added 100 cc. of concentrated hydrochloric acid. After warming to 50° to 60° the insoluble polymer of thiocyanogen was removed by filtration and the 1-imino-3-chloro-5 methyl benzthiazole precipitated from the chilled fil-

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1. Dyson, Hunter and Morris, J. Chem. Soc., *130*, 1186); Kaufmann, Arch. Pharm., *266*, 197 (1928); Likhosherstov and Petrov, J. Gen. Chem. (U. S. S. R.), *3*, 183 (1933); Kaufmann and Kuchler, Ber., *67*, 944 (1934).

2. Brewster and Dains, J. Amer. Chem. Soc., *58*, 1364 (1936).

trate by the addition of ammonium hydroxide. This was collected on a filter, washed with water, dried and recrystallized from ligroin. The melting point of the pure product was 185° and the yield was 10 g., which is 50% of the theoretical quantity.

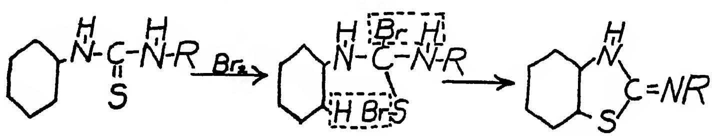
Other substances which were prepared by the same process are shown in Table I. It will be noted that 2-nitro-4-methyl-aniline and 2-4-dinitroaniline did not undergo thiocyanogenation. The reaction in these instances failed completely. These observations are in accord with the results of Brewster and Dains in attempts at the cyanogenation of 2-4 disubstituted anilines in which the ortho substituent was a nitro group or of 2-chloro-4-nitro aniline. In these compounds "steric hindrance" forces are very large.

TABLE I

No.	Benzthiazole.	Source.	Per-cent yield.	Mp.	Percent N.	
					Calcu-lated.	Found.
1	1-Imino-3-Methyl-5-bromo.........	2-Me-4-Br-aniline...........	67	213°	11.53	11.44
2	1-Imino-3-Chloro-5-methyl.........	2-Cl-4-Me-aniline............	50	185	14.10	14.05
3	1-Imino-3-5-dichloro...............	2-4-Dichloroaniline..........	45	260	12.80	12.90
4	1-Imino-3-Chloro-5-bromo..........	2-Cl-Br-aniline..............	35	247	10.63	10.79
5	1-Imino-3-bromo-5-chloro...........	2-Br-4-Cl-aniline............	35	251	10.63	10.55
6	1-Imino-3-nitro-5-methyl...........	2-NO_2-4-Me-aniline..........	0	......	....	....
7	1-Imino-3,5-dinitro................	2-4-Dinitroaniline	0	......	....	....
8	1-Imino-5-phenyl...................	4-Aminobiphenyl............	65	225	12.40	12.28

Another method for the production of this type of thiazole consists in the action of bromine upon a disubstituted thiourea as used by Hugerschoff[8] with thiocarbanilide and other symmetrical disubstituted thioureas. If the radical (R) is also of aromatic character then there are two possible methods of ring closure which may be illustrated in figures 2 and 3.

2



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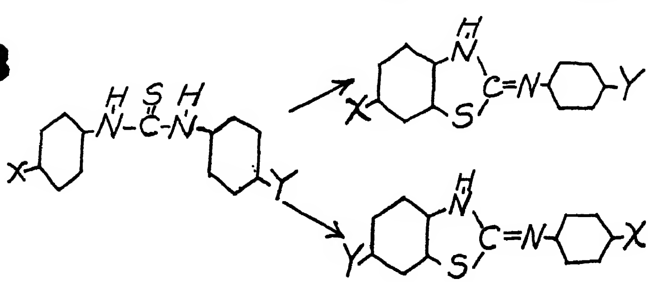


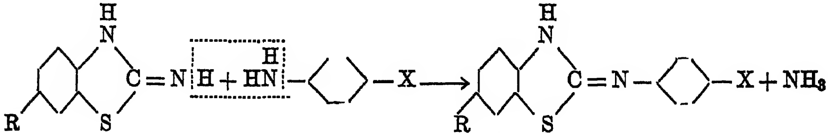
8. Hugerschoff, Ber. *36*, 3121 (1903).

Several such disubstituted thioureas were prepared by us and treated with bromine in order to determine which type of ring closure was obtained. A typical experiment is here described. The N-phenyl-N′-p.-biphenyl thiourea was prepared by addition of phenyl isothiocyanate to p-aminodiphenyl and 30 g. (0.1 mole) of this thiourea was dissolved in 500 cc. of chloroform. To this solution, which was mechanically stirred at room temperature, was slowly added a solution of 16 g. (0.1 mole) of bromine in 100 cc. of chloroform. The color of the bromine disappeared without the formation of any precipitate and after the addition of 30 g. of sodium carbonate in 200 cc. of water, the chloroform was removed by distillation in steam. The solid thiazole derivative which remained in the distilling flask was brought onto a filter, washed and recrystallized twice from ligroin. The pure 1-p-biphenylimino-benzthiazole melted at 195°. The isomeric compound 1-phenylimino-5-phenyl benzthiazole (prepared by fusion of 5-phenyl-benzthiazole with aniline) melted at 186° and a mixture of the substances melted between 160° and 165°, hence the ring closure occurred at the phenyl group leaving the biphenyl radical at position 1. A list of other benzthiazoles which were prepared by this reaction with bromine upon the thioureas is shown in Table II.

TABLE II

No.	Benzthiazole.	Source (Thiourea).	Per-cent yield.	Mp.	Percent N.	
					Calculated.	Found.
9	1-p-Biphenylimino..................	N-Phenyl-N′-p-biphenyl......	80	195°	9.27	9.22
10	1-Cyclohexylimino..................	N-Phenyl-N′-cyclohexyl......	75	110	12.06	12.13
11	1-p-Phenoxyphenylimino-5-methyl...	N-p-Tolyl-N′-p-phenoxyphenyl	90	175	8.43	8.39
12	1-p-Biphenylimino-5-methyl........	N-p-Tolyl-N′-p-biphenyl.....	90	191	8.86	8.93

As a check upon the constitution of the benzthiazoles listed in Table II, another method of their formation, developed by Brewster and Dains, was employed. This method utilizes the fusion of an aromatic amino compound with an 1-iminobenzthiazole and results in the formation of an 1-arylimino-benzthiazole with liberation of gaseous ammonia.



Thus 8 g. (0.5 mole) of 1-imino-5-methyl-benzthiazole and 9 g. (0.5 mole) of p-aminodiphenyl ether when heated in an oil bath at 180° to 200° for one hour evolved ammonia and gave 1-p-phenoxyphenylimino-5-methyl-benzthiazole (compound No. 11). This product and the sample obtained by action of bromine upon the thiourea (Table II) were identical, as was shown by no lowering of the melting point upon mixing the two specimens. Similar experiments proved the identity of each compound listed in Table II.

SUMMARY

A comparison of the yields of the benzthiazoles obtained by thiocyanogenation of the aromatic amines (Table I) shows the relative hindering effects of different radicals. The nitro group has the greatest steric hindrance and is followed in turn by bromine and chlorine. In the cases of formation of thiazoles by the action of bromine upon the thioureas (Table II) it is notable that the ring closure was always to the phenyl or p-tolyl group. No detectable amount of the opposite compounds was produced.

The Identification of Soil Insects by Their Burrow Characteristics [1]

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The writer became interested in the burrowing activities of insects and their burrow characteristics while conducting investigations pertaining to the abundance and distribution of subterranean insects. Excavations and surveys made to determine the populations, food habits, and distribution of wireworms (Elateridae) and white grubs (Scarabaeidae) often revealed the presence of burrowing bees, wasps, beetles, larvae, earthworms and spiders in the areas under observation. Observations convinced the writer that the diameter, length, location, contents and the manner in which the excavations were made may be used as characters to identify the insect responsible for the burrow once the proper species has been associated with its work. A knowledge of these facts is important as a time-saving device when one is making a study of burrowing insects in the field.

McColloch and Hayes (1922) called attention to the fact that there is a reciprocal relationship between insects and soil and that the soil is important as an environment for insect life. Bryson (1924) pointed out the interrelations which exist between insects and the soil. Dillon (1938) showed that some soil insects, such as the corn seed beetle, *Agonoderus pallipes* Fabr., frequent crevices in the soil to escape high temperatures in the summer time. Crickets and ground beetles frequently crawl into crevices, depressions in the soil or into burrows of higher animals to escape their enemies or the effects of adverse weather conditions.

Many insect larvae burrow through the soil, but leave no evidence at the surface to indicate their presence. The soil is packed along the sides of the burrow to permit the larvae to progress through the soil. This is the method employed by the wireworms, false wireworms, white grubs and other pests which attack the roots of staple crops. No entomological X-ray has been devised by which the presence, habits and activities of subterranean insects may be studied. Only the robins, skunks and other wild animals appear to possess the instinct of knowing where an infestation of grubs is located without first making an excavation.

Probably the most important reason soil insects excavate burrows is to provide a suitable home in which the young may be reared. Soil temperatures do not fluctuate greatly from day to day; hence, the extremes of temperature are not so severe as those of the atmosphere above the surface of the soil. A recording soil thermograph recorded a daily maximum temperature of 83°F, six inches below the surface for a period of one week during the summer of 1936 while the daily maximum air temperatures at Manhattan varied from 111° to 115° F. This lower soil temperature when compared with that of the

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1. Contribution No. 475, Department of Entomology. This paper embodies some of the results obtained in conducting staple crop insect investigations on Project 100 Hatch. Acknowledgement is hereby made to Mr. Dick Schwitzgebel, who made the diagrammatic drawings of the burrows.

atmosphere indicates that the soil environment would be more suitable for the growth of delicate larvae than the air temperatures at the surface. The moisture conditions which usually prevail in the soil also contribute to the suitability of the soil environment as a habitat for larvae which require a permanent burrow in which to undergo development.

Permanent burrows are usually located in soil which is sufficiently firm to prevent the collapse of their walls. Naturally, larvae which spend their lives within the confines of the burrow must have some provision to obtain food. The food must be stored within it for them, supplied from time to time, or the burrow must be located where food may be reached readily by the larvae.

METHODS

When burrows were encountered, an attempt was made to observe and record all of the information which could be used in the identification of the burrow at some future time. In order to accomplish this, it was necessary to collect data regarding the diameter, length, form and location of the burrow, the structure of the excavated soil and the nature of the materials stored in the burrows. The soil mounded over the entrance to the burrow was carefully collected, air dried, weighed and studied. Sketches were made to illustrate some of the representative burrows of several of the species encountered.

Notes were taken in regard to the location of the burrow and the manner in which the soil was mounded or scattered around the entrance. The shape and appearance of the pellets of the excavated soil were also recorded. In order to trace the direction of each burrow during the process of excavation, it was necessary, first, to insert a small twig, weed stem, straw or a small rubber tube into the burrow. This was possible only in cases where the burrow was open. Burrows which were partially filled with soil were more difficult to follow. Usually, a wire with a blunt end could be forced through the loose soil within the burrow.

PRESENTATION OF DATA AND DISCUSSION

This presentation is not intended to be an exhaustive treatise on the characteristics of the burrows made by all insects which might be found burrowing in the soil. Sufficient data and examples are presented to show how the various characters may be used in making a study of burrowing insects in the field.

Most species of ants make characteristic mounds. The size of the mounds, the manner in which the soil particles are arranged and the size of the particles are sometimes indicative of the species. The occurrence of certain mounds of ants near corn plants in a cornfield are usually indicative of the presence of the cornfield ant, which is so intimately associated with the life activities of the corn-root aphids. The mound building prairie ant, so common in western Kansas, may be recognized by the character of materials which it collects and adds to its mound. The manner in which the vegetation is cleared away from the area immediately surrounding the mound is also a characteristic which may be used to identify this species.

Bembex spp. are solitary wasps which are gregarious in habit because several individuals may construct burrows on the same area. The location of their

burrows is a characteristic feature of the species. The excavations are usually located in barren, dry areas such as abandoned roads, hog lots, or barn lots. They are numerous on sand-dune areas. Since the adult provisions and reprovisions their burrows with flies, there is an advantage in constructing such burrows near feed lots or dwellings where flies are abundant. They do not, however, use one species of flies exclusively, but utilize species in different families.

Rau (1918) has admirably described the activities of these wasps in the field, while Peckham (1905) presented an interesting description of the burrowing activities of some of the social and solitary wasps. Wheeler (1930), in his book "Demons of the Dust," describes the ecological conditions which determine the suitability of desert soils as a home for insect life.

These solitary wasps construct a burrow as indicated in figure 1. At the end of the burrow the young larvae lives and develops to maturity. After the excavation is made, a supply of flies such as bee flies, stable flies, houseflies, flesh flies, etc., are stored in the burrows. At intervals a new supply of flies must be supplied and this necessitates reopening the burrow. In this instance, the excavated soil is scattered and leveled down until it is difficult to find the entrance. A rain will sometimes destroy the concealment of the entrance, and as a result, swarms of these wasps will be seen actively engaged in restoring to normal the surface of the soil over and about the entrance. The presence of the burrow can sometimes be detected by the scratched appearance of the surface soil and the loosely scattered soil, even though the exact entrance to the burrow is not easily discernible.

The cicada killer, *Sphecius speciosus* Drury belongs to the same family as do the other bembecine wasps just described, but in most instances it excavates an entirely different type of burrow. Instead of a shallow, sloping burrow, the burrow is deep and almost straight after making a corkscrew turn just below the surface. All of the soil is removed, leaving the cavity open except for a space at the lower extremity of the burrow occupied by the stored cicadas (figure 2). While in the process of excavation, the entrance is seen in the center of the mound of soil and is plugged only on completion. In many instances one-half tea cup to one pint of finely granulated soil is excavated. The diameter of the burrow is large enough to accommodate the cicadas to be stored as food for the developing larva. This insect confines its burrowing activities to the summer season when cicadas are available.

The larvae of *Harpalus caliginosus,* family Carabidae, excavates a J-shaped burrow similar to the one illustrated in figure 3. The burrows usually average six inches in length and have the excavated soil over the entrance. These burrows are good examples of a combination of the open and closed type. About four inches of the burrow is closed with the excavated soil, while a two-inch cavity is left at the distal end and it is in this portion of the burrow that the larva may be found. The excavated soil is coarse and granular.

Tiger beetle larvae, for example, live singly in vertical burrows with sufficient diameters to permit the larvae to move readily up and down in the burrow (figure 4). These larvae enlarge and deepen their burrows as necessity demands. Their burrows are constructed usually in a path or bare open spaces where crawling insects are likely to pass. The larva waits, with its head closing the entrance to the burrow and grasps an unfortunate insect scurrying past.

The larvae deepen the burrows and occasionally cleans them out after a heavy rain. The soil is thrown out in course pellets, usually some distance on one side of the entrance. If the soil was piled near the entrance, it would interfere materially with the larva's attempt to obtain food. Many insects crawling along on the smooth surface of the soil often go around small amounts of freshly excavated soil. If the surface soil is black where the burrow is constructed while the excavated pellets are yellow, red or some color other than black, it can be safely assumed that the burrow extends into the soil for some depth. Many tiger beetle larval burrows extend vertically into the soil to a depth of 15 to 18 inches (figure 4).

The mouth of the tiger beetle's burrow has its edges rounded and the head of the larva is placed horizontally across the opening so that the entrance is completely closed when the insect is lying in wait for its prey. Thus it may be seen from the foregoing description that the arrangement of the soil particles, size of the pellets, size of the entrance, color of the particles and the location of the burrow are all characters which may be used in the identification of the insect responsible for the burrow.

If the surface of the soil is examined after a rain in the summer or in the morning during the season of the year when the soil is not frozen, large numbers of small meandering burrows may be seen on the surface of the soil. These burrows have been made by small ground beetle larvae searching for organisms at the surface of the soil. Usually, these burrows are more numerous on soil which contains a considerable amount of organic matter. The excavated soil appears granular in form. Beneath the excavated soil is to be found a small groove which is two inches to 10 inches long and wider at one end than at the other. Counts have revealed as many as 75 to 100 per square yard. These small larvae are performing these burrowing activities in search of food which consists of animal or plant organisms present in the soil.

These larvae are among the first animals to burrow after the frost goes out of the ground in the spring. Their burrows are often mistaken for those of earthworms which deposit smooth rounded pellets or castings upon the surface. In this instance, not only the size and shape of the burrow (fig. 5), and character of the excavated soil may be used to identify the insect, but also the placement of the burrow on the surface of soil rich in organic matter.

A visit to any sand-dune region such as the one located at Medora, Kan., will reveal the presence of a large number of small mounds about the same size. The quantity excavated in each case is about enough to fill an ounce box. When the mound is carefully removed, no burrow will be found because the ground beetle, *Goepinus fluviaticus* Csy., which makes the excavation removes only the soil in the first 3 to 4 inches of the burrow and forces it upward over the entrance. Bryson (1931) made some studies of the burrowing habits of this species while the insects were confined in a burrowing cage. This space in the burrow is cleared of soil and the beetle progresses downward at an angle of about 45 degrees; the sand is pushed backward filling the space previously occupied by the excavated soil. The beetles are nocturnal in habit and construct these burrows each morning to escape the heat of the day; they dig in from daylight until 9 or 10 o'clock in the morning, depending upon the air temperature.

The burrow is closed except for the 3 or 4-inch cleared space occupied by

the beetle as indicated in figure 6. Hence, the uniformity in the size of the mounds of sand, number of mounds, no open burrow beneath the mound and the time of day that the burrowing is done are all characters which may be used to identify the presence of beetles belonging to *Geopinus fluviaticus* Csy.

On barren, sandy areas frequented by rabbits there occurs a large number of small black dung beetles, *Canthon lecontei,* which bury pellets of rabbit dung. These small beetles usually work in pairs and roll the pellets of dung to the location where they are to be buried. The beetles undermine the pellet once it is rolled to a suitable burial place. This allows the pellet to sink by its own weight as the loose sand is worked upward until it envelops the dung. The volume of sand comprising the mound is about the size of a garden pea. The arrangement of the soil particles in the mound presents the appearance of having been finely divided by the burrowing activities of the insect. The size, shape and general burrow characteristics are illustrated in Figure 7. Lindquist (1933) has illustrated the type of burrows made by several species belonging to the tribe *Coprini.*

Beetles belonging to the genus *Bolbocerasoma* (*Scarabaeidae*) excavate burrows in hard, compact soil, usually with a claylike consistency. The burrows often exhibit a V-shaped effect, with two openings 3 or 4 inches apart, (fig. 8). As the beetles excavate, the soil is forced upward in small quantities. Since the beetle works in soil with a claylike consistency, the particles adhere to each other, so the excavated mass possesses the appearance of having been bored out by a small soil auger.

There are a number of burrowing spiders which construct burrows in the soil. In most instances the burrows are lined with silk, which lining projects above the surface of the soil to resemble a small chimney. The soil is expelled from the mouth of the burrow in a circular manner to form a ring about the entrance. The pellets appear angular and resemble granules of coarse blasting powder. The burrow is usually dug almost straight downward. Figure 9 illustrates the arrangement of the particles of soil about the entrance, the size and direction of the burrows.

Throughout the year ground beetles, cutworms, May beetles and many other insects burrow into the soil in order to escape adverse weather conditions. The tomato worm, corn-ear worm, and other larvae which have spent their entire larval period above the surface of the soil, burrow into it in order to pupate. Many adult insects burrow into the soil to deposit eggs.

It is not feasible here to describe in detail the appearance, size, location and other characteristics which could be used to identify the presence of these insects on a given area. The illustrations and discussion presented serve to show that practically all of the burrowing insects which leave at the surface a visible record of their presence, exhibit certain burrow characteristics which may serve to identify them.

Following is a table which gives in summary form, pertinent information regarding the sizes of the burrows, type of burrows constructed, kind of soil in which the burrows are ordinarily found, direction of the burrow and the average amount of soil based upon weights of excavated soil from 10 burrows. These data were taken after the burrows were completed and are representative of those excavated by the insects previously described.

TABLE I.—Characteristics of representative burrows of some burrowing insects

BURROWING INSECTS.	Diameter in inches.	Length in inches.	Type of burrow.	Kind of soil.	Direction of burrow.	Weight of soil in grams.
Bembex spp.	0.25	10.0	Closed	Excavate in clay and loam	45° angle	25.2
Canthon lecontei	0.20	1.5	Closed	Sandy soil	Vertical	1.3
Tiger beetle larvae (unidentified)	0.20	12–15	Open	Clay or sandy soil	Vertical	3.7
Geopinus fluviaticus	0.31	3–4	Closed	Sand-dune region	45° angle	6.07
Cicada killer	0.83	13	Open	Usually in packed clay	Tortuous	60.0+
Bolbocerasoma spp	0.25	10	Open	Usually in packed clay	Y-shaped	20.0+
Spiders	0.5	10	Open	In loam or sand	Vertical	15.0+
Ground beetle larvae (species undetermined)	0.125	3–10	Open	Soils rich in organic matter	Horizontal (on surface)	3.5+
Haraplus caliginosus	0.25	6–7	Partly closed,	Loam soils	Curved	14.25

SUMMARY

1. A study of burrows constructed by a large number of species of burrowing insects which leave a trace of their activities at the surface would indicate that they excavate burrows for various reasons; namely, to deposit eggs and rear their young, store provisions for future use, secure food, escape the effects of adverse weather conditions, construct homes and to escape their enemies.

2. The characteristics of the excavated burrows are so definite that after some study in the field, an investigator can learn to identify the species of insect responsible for the work by the manner in which the soil has been excavated. The characteristics which may be used include the following:

(*a*) Size of burrow which should include its diameter and length.
(*b*) Shape and characteristic turns in the burrow.
(*c*) Location or placement of the burrow, especially in relation to the nearness of a food supply.
(*d*) By the size, weight and arrangement of the soil particles at the entrance.
(*e*) The amount, structure and type of soil excavated.
(*f*) Character of the interior of the burrow.
(*g*) Quantity and nature of materials stored in the burrows.

3. If the foregoing discussion has been emphasized sufficiently to awaken the interest of the reader in the activities of burrowing insects and their conformity to a definite plan in the construction of burrows, the realization that every opening in the soil or mound of earth made by insects did not merely happen that way but was accompanied by a scene of life activity in response to the behavior plan of some burrowing insect, the object of this presentation will have been achieved.

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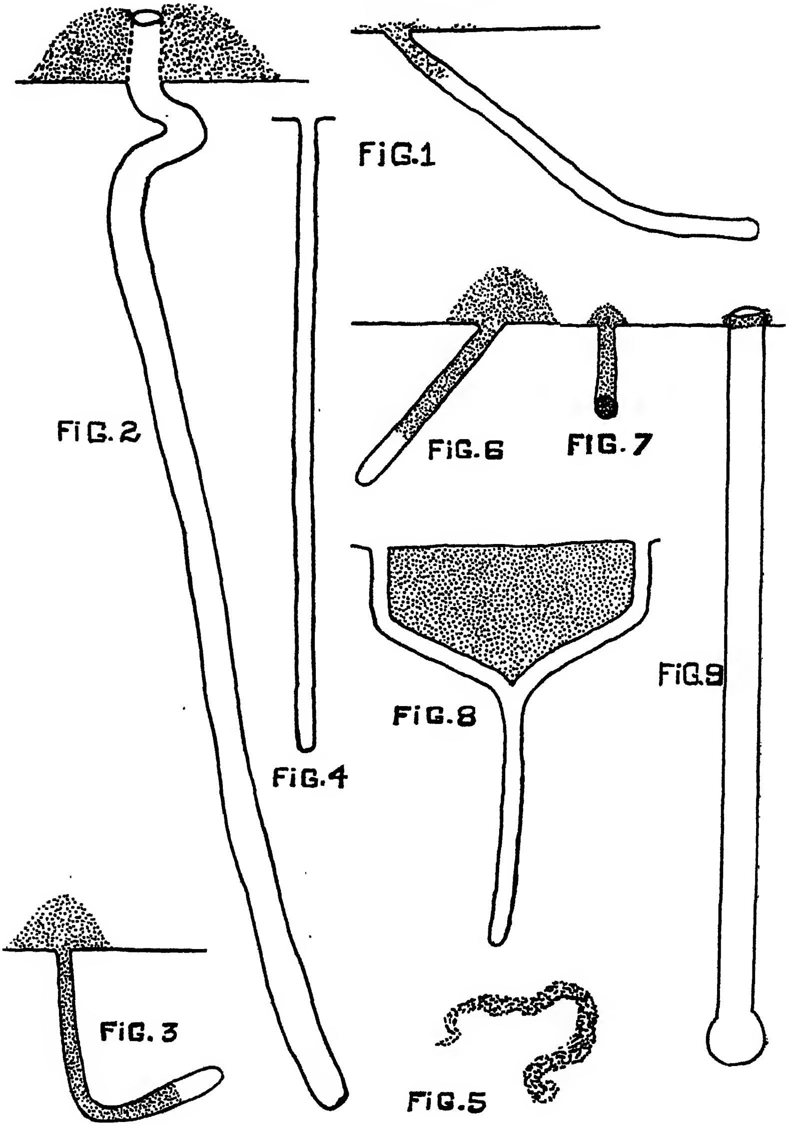
EXPLANATION OF FIGURES

Diagrams of representative burrows to show burrow characteristics described in the table. (About one-fourth size.)

1. Bembex.
2. Cicada killer.
3. Larvae (*Harpalus caliginosus*).
4. Tiger beetle larvae.
5. Ground beetle larvae.
6. *Geopinus fluviaticus*.
7. *Canthon lecontei*.
8. Bolbocerasoma spp.
9. Burrowing spider.

FIGURES 1 TO 9



Biological and Taxonomic Observations on the Mosquitoes of Kansas [1]

MRS. NOBLESSE DEMOSS HILL, Manhattan, Kan.

The work reported herein consisted of studying approximately 600 specimens of mosquitoes received from Kansas University and the 300 specimens in the Kansas State College collection. The writer collected, reared and studied the life histories and habits of mosquitoes in Kansas, from April, 1936, to July, 1937. Field observations were hampered because of the continued cold weather in the spring of 1936 and of 1937, and the extremely dry weather during the summer of 1936.

The aims of this study were: (1) to make a complete list of the species of mosquitoes in Kansas as shown by the literature and collections available; (2) to bring together the facts known about the mosquitoes of Kansas; (3) to make available additional information on the habits, biology, economic importance and distribution of all species; and, (4) to prepare a key to the species in Kansas, using superficial and easily recognized characters, so that the key may be used by the beginning student as well as by laymen.[2]

A survey of the literature shows that little work has been done with the mosquitoes of Kansas. The only published report is that of Overman (1906) who listed 14 species for Douglas county, of which representatives of seven were not found during the present work. The species which Overman listed are as follows: Aedes (*Culex*) *sollicitans* (Walk.); *C. inconspicuus* (Grossbeck), now *Aedes trivittatus; Theobaldia* (*Culex*) *C. melanurus* (Coq); *Mansonia* (*Culex*) *perturbans* (Walk.); *Aedes* (*Culex*) *stimulans* (Walk.); *Aedes* (*Culex*) *impiger* (Walk.); *Orthopodomyia* (*Culex*) *signifer* (Cog.); *C. consobrinus* (Desv.), now *C. pipiens;* and *C. restuans* (Walk.), now *C. territans* (Walk.). No specimens studied or collected by Overman (1906) were found in the Kansas University collection.

Information about mosquitoes of Kansas is included in the general accounts of Matheson (1929) and Howard (1900).

In this study 18 species of mosquitoes were found to occur in Kansas, 11 of which are annoying to man, two malarial, and five which are of no known economic importance. Eight new county records and 10 new state records of distribution are given. The most common species throughout the state apparently are *Psorophora ciliata* (Fab.), *Anopheles punctipennis* (Say), *Aedes vexans* (Meig.), and *Aedes nigromaculis* (Ludl.).

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Contribution No. 473 from the Department of Entomology. This paper was prepared from a master's thesis at the Kansas State College of Agriculture and Applied Science. The writer gratefully acknowledges the assistance of a $25 grant by the Kansas Academy of Science in 1937 to aid in collecting mosquitoes in the state and in preparing this finished report.

2. The writer is indebted to Dr. R. C. Smith, the major instructor in this work; to Dr. Alan Stone for classification of specimens; to Dr. R. H. Beamer, Dr. R. H. Painter, Dr. R. L. Parker, Prof. George Dean and Mr. R. C. Brown, and to many others for specimens and other help given during the study.

Anopheles punctipennis (Say) appears to be the most common malarial mosquito, but it and the two species of Aedes were rare in Riley county during the time of these observations. *Culex tarsalis* Coq. and *C. territans* Walk. were the most common two species found in Riley county.

All the immature stages which were found occurred in artificial containers, which may not have been the normal breeding places for the particular species. Streams, ponds and other bodies of water, which are normally prolific breeding places for certain species, were free from mosquitoes of any species.

The places in which most of the immature stages were found were containers such as large galvanized buckets, wheelbarrows and earthen crocks filled with water and placed in favorable locations. The immature stages of mosquitoes were collected at least twice a week.

The adults were collected with small chloroform vials, cyanide bottles, and with a New Jersey mosquito trap. The eggs, larvae and pupae were collected with a long-handled tea strainer and a galvanized dipper. The immature stages were transported to the laboratory for rearing in quart jars filled with some of the water from which they were taken, sealed loosely, and labeled. Mason jars and large two-gallon food jars, covered with cheesecloth or screen were used for rearing the adults. The jars were set out of doors in a shady, grassy place. The mounted specimens were sent to Dr. Alan Stone at Washington, D. C., to be identified.[3]

3. Full descriptions of the species found in Kansas are not given here because adequate descriptions may be found in the publication of Dyar, (1922) and Matheson (1929).

TABLE I.—Summary of the data on the mosquitoes of Kansas

NAME OF SPECIES.	Distribution.	Relative number.	When reported.	Economic importance.
Aedes triseriatus Say	Eastern part of state (Douglas and Riley counties)	Scarce	By Dyar (1922) Lawrence, Kan.	Pestiferous.
Aedes vexans Meig.	Throughout state	Abundant	By Dyar (1922) Kansas City, Kan.	Pestiferous.
Aedes nigromaculis Ludl.	Throughout state	Abundant	First report for state	Pestiferous.
Anopheles punctipennis (Say)	Throughout state	Fairly common	First report for state	Carrier of malaria.
Anopheles pseudopunctipennis Theo.	Eastern portion (Riley county).	Rare	First report for state	Of no known economic importance.
Anopheles quadrimaculatus Say	Eastern portion (Lawrence, Kan).	Scarce	First report for state	Malarial.
Theobaldia inornata (Will.)	Eastern and southwestern portion.	Abundant	By Dyar (1922) Lawrence, Kan.	Does not attack man, but larger animals.
Culex apicalis Adams	Eastern portion (Riley county).	Rare	First report for state	Of no economic importance.
Culex tarsalis Coq.	Northern and eastern portion,	Abundant	By Dyar (1922) Wellington, Kan.	Pestiferous.
Culex territans Walk.	Eastern portion	Rare	First report for state	Pestiferous.
Culex pipiens Linn.	Eastern portion	Rare	First report for state	Pestiferous.

TABLE I.—Summary of the data on the mosquitoes of Kansas—*Concluded.*

NAME OF SPECIES.	Distribution.	Relative number.	When reported.	Economic importance.
Culex quinquefasciatus Say..................	Eastern portion............	Rare............	By Dyar (1922) Lawrence, Kan...	Pestiferous.
Megarhinus septentrionalis (Dyar and Knab)...	Eastern portion............	Rare............	First report for state............	Of no economic importance.
Psorophora ciliata Fab.....................	Throughout state...........	Abundant........	By Dyar (1922) Manhattan, Kan.	Pestiferous.
Psorophora columbiae (Dyar and Knab).......	Eastern portion............	Scarce..........	First report for state............	Bite, but without leaving irritation.
Psorophora cyanescens Coq..................	Northern and central portion,	Scarce..........	By Dyar (1922) Wellington, Kan.	Pestiferous.
Psorophora horrida (Dyar and Knab).........	Eastern portion (Douglas county).	Rare......	First report for state............	Nothing is known of its economic importance.
Psorophora signipennis (Coq.)...............	Eastern half...............	Fairly common....	First report for state............	Unknown.

KEY TO THE SPECIES OF MOSQUITOES KNOWN TO OCCUR IN KANSAS

A. Wings spotted.
- B. Wings white spotted.
  - C. Tarsi banded white.
    - D. Abdomen with dirty-yellow, triangular, apical, segmental bands. *Psorophora columbiae*
    - DD. Abdomen with median, yellow, basal, segmental bands except the last segment, which is wholly black. *Aedes nigromaculis.*
  - CC. Tarsi not banded.
    - D. Palpi marked with white. Third vein (R_{4+5}) of wing extensively white in the middle. *Anopheles pseudopunctipennis.*
    - DD. Palpi wholly black; third vein (R_{4+5}) wholly black. *Anopheles punctipennis.*
- BB. Wings black spotted.
  - C. Beak widely banded in middle. *Psorophora signipennis.*
  - CC. Beak not banded, but slender, dark brown to black. *Anopheles quadrimaculatus.*

AA. Wings not spotted.
- B. Abdomen with dorsal or lateral bands or both.
  - C. Abdomen with basal bands or spots.
    - D. Tarsi with bands or with light markings.
      - E. Large species, brilliantly colored; with long, rigid, downward curved beak. *Megarhinus septentrionalis.*
      - EE. Smaller species. Beak normal.
        - F. Beak dark with white ring near middle. *Culex tarsalis.*
        - FF. Beak slender, black. *Aedes vexans.*
    - DD. Tarsi not banded.
      - E. Mesonotum with bare, impressed, gray lines, or cross-veins of wing tend to lie in line—anterior close to posterior. *Theobaldia inornata.*
      - EE. Mesonotum without such lines, but either of uniform color or otherwise marked.
        - F. Mesonotum marked with snowy white scales on the sides. *Aedes triseriatus.*
        - FF. Mesonotum with light scales or of an uniform dark color.
          - G. Basal white band of the second abdominal segment usually not triangular produced medianly. *Culex territans.*
          - GG. Basal white band of the second abdominal segment usually triangularly produced medianly.
            - H. Abdominal bands joined to lateral spots. *Culex pipiens.*
            - HH. Abdominal bands separated from lateral spots. *Culex quinquefasciatus.*
  - CC. Abdomen with apical bands or spots.
    - D. A black or dark brown mosquito with light markings. First tarsal segment pale banded. *Culex apicalis.*
    - DD. Beautifully colored mosquito. Either blue or purple with golden markings.
      - E. Tibia and tarsi of hind legs with raised, outstanding scales. Last two joints of tarsus snowy white. *Psorophora horrida.*
      - EE. Hind legs smooth, without erect scales. Tarsi not white. *Psorophora cyanescens.*
- BB. Abdomen not banded, but brown scaled with scattering white scales especially towards the tips of the segments. *Psorophora ciliata.*

The following species occur in border states, therefore there is a probability that they may be found in Kansas.

Anopheles barberi Coq. Dyar, 1922, p. 108.
Aedes idahoensis Theo. Dyar, 1922, p. 61.
Aedes pullatus Coq. Dyar, 1922, p. 53.
Aedes hirsuteron Theo. Dyar, 1922, p. 61.
Aedes dorsalis Meig. Dyar, 1922, p. 69.
Aedes thibaulti Dyar and Knab. Dyar, 1922, p. 82.
Culex degustator Dyar. Dyar, 1922, p. 13.
Culex pungens Wied. L. O. Howard, 1900, p. 30 = *Culex quinquefasciatus* Say.
Mansonia perturbans Walk. Dyar, 1922, p. 31.
Psorophora sayi Dyar and Knab. Dyar, 1922, p. 31.
Psorophora discruceans Walk. Dyar, 1922, p. 37.
Orthopodomyia signifer Coq. Dyar, 1922, p. 96.

Dr Alan Stone reports that specimens of *Culex degustator* Dyar from Kansas are in the collection at Washington, D. C.

Aedes nigromaculis (Ludl.)

A rather large, black mosquito with black-and-white banded legs.

Habitat and Habits. Only the adults of this species were collected during this study and were found in the summer and fall months. The females are severe biters.

This species is fairly common in Kansas. It has been collected in the following localities: Dickinson county, July 16, 1923 (W. B. Whitlow); Douglas county, (R. H. Beamer); Clark county, May (F. H. Snow); Franklin county, June 8, 1923 (R. H. Beamer); Lyons county, June 6, 1923 (R. H. Beamer); Arcola, July 20, 1929 at light (R. H. Painter); Manhattan, September 25, 1930, July 1, 1921 (R. C. Smith), October 11, 1938 (Oliver Miller).

The occurrence of this species in Kansas is being reported for the first time.

Aedes triseriatus (Say)

A small, black mosquito with silvery white markings.

Habitat and Habits. The adults of this species, though an uncommon species, were collected in May, June and September. Some adults were collected while swarming aroung a tree stump in Manhattan. The females are severe biters.

This species was reported from Lawrence by Dyar, and since Dyar's report (1922), has been taken at Lawrence by H. T. Martin, and at Manhattan, June 17, 1937, by N. A. DeMoss.

Aedes vexans (Meig.)

A dark brown mosquito with white banded legs and abdomen. The bands on the abdomen are notched.

Habitat and Habits. This species is pestiferous and is on the wing from early spring to late fall in wooded areas, grassy and weedy places particularly. A few larvae were taken from a fish bowl in August, 1936, at Manhattan. It is one of the most common in Kansas, although it was not so abundant during the time this work was done. It has been found in the following localities:

Douglas county (F. H. Snow) June (E. S. Tucker); Atchison county, July 11, 1924 (R. H. Beamer); Phillips county, August 20, 1912 (F. X. Williams); Sheridan county (F. X. Williams); Doniphan county, July 20, 1924 (R. H. Beamer); Pratt county, June, 1921; Gray county July and September 15, 1927; Stafford county, April 20, 1928 (E. M. Painter); Arcola, July 20, 1929 (R. H. Painter); Manhattan, September 19, 1936 (N. A. DeMoss), October 1, 1926 (R. H. Painter), May, 1934 (R. C. Smith); Franklin county, April 22, 1923 (H. K. Gloyd).

Dyar (1922) reported this species from Kansas City only.

Anopheles punctipennis (Say)

A medium-sized, black mosquito with characteristic, black wings, spotted white.

Habitat and Habits. This species may be a carrier of malaria; it has been found infected in nature; it was found in the late summer and fall months only, and is fairly evenly distributed throughout Kansas. It has been collected in the following localities: Douglas county, November 14, 1903 (R. L. Moodie); Doniphan county, July 20, 1924 (R. H. Beamer); Onaga, November 24, 1925 (F. F. Crevecoeur); Arcola, July 20, 1929 (R. H. Painter); Riley county, June, 1936 (N. A. DeMoss); Pottawatomie county, July 4, 1936 (R. H. Painter).

This species was reported by Dyar (1922) as occurring at Onaga only.

NOTE: A specimen labeled *Anopheles maculipennis* Meig., collected by F. H. Snow in Douglas county, occurs in the University of Kansas collection, but Matheson stated in a letter that the identification was incorrect.

Anopheles pseudopunctipennis (Theob.)

Similar to *Anopheles punctipennis* (Say) in color and size, but differs from it in the spots on the wings.

Habitat and Habits. This mosquito is rare in Kansas. The few adults found were collected in Manhattan October 28, 1925. These specimens are in the Kansas State College collection. This is a Southern species and is reported for the first time as occurring in Kansas.

Anopheles quadrimaculatus (Say)

A medium-sized black mosquito with four black spots on the wings.

Habitat and Habits. This species has been uncommon in Kansas. The adults were collected inside a house, about three miles east of Lawrence, in June and August, 1936. It is a dangerous malarial mosquito.

Theobaldia inornata (Will.)

A large, brown mosquito.

Habitat and Habits. This species was found from early spring to late fall, and in most cases, was found breeding in artificial receptacles. Some adults were found sucking blood from a horse.

Life History. The eggs are laid in large, triangular rafts on the surface of the water and hatch in 48 hours. The larvae feed on microscopic organisms in the water. The length of the larval period is approximately eight days and the pupal period three days.

This species is common in Riley county and also was collected in the following localities: Douglas county, November 11, 1936 (N. A. DeMoss); March 23, 1919 (W. Hoffman); Clark county May (F. H. Snow); Riley county, August, 1936 (N. A. DeMoss), September 27, 1932 (D. R. Musser), April 19, 1937 (N. A. DeMoss).

Culex tarsalis (Coq.)

A medium-sized mosquito with characteristic white markings.

Habitat and Habits. This species was found to be on the wing in Kansas from the early part of May to early December and are least common during the summer months. It was found breeding in many types of habitats but mostly in artificial containers.

Life History. The eggs are small, triangular, boat-shaped rafts, laid on the surface of the water and hatched in twenty-four hours. The length of the larval period is from five to seven days, and the pupal period approximately two days.

This species is common in Riley county and throughout the state. It has been collected in the following places: Sedan, November 11 (in K. U. Collection); Douglas county, June and December (N. A. DeMoss); Clay county, September, 1936 (N. A. DeMoss); Riley county, September, 1936 (N. A. DeMoss); October 19, 1938 (N. A. DeMoss); May 19, 1938 (Axtell); Harvard Cave, Sun City, March 11, 1937 (Hobart M. Smith).

Dyar reports this species from Lawrence only.

Economic Importance. The adult female is a hard, persistent biter. Whenever this species appears in large numbers it becomes a nuisance, and was found to bite in the day as well as at night.

Large broods of this species appeared after a big rain in July, 1936. They were a nuisance for three or four nights in East Manhattan. After this time only a few could be found on the wing.

Culex territans (Walk.)

A medium-sized, blackish-brown mosquito with characteristic white marking.

Habitat and Habits. The adults were found as early as April and as late as October. The greatest number was found during the latter part of August and first part of September. The adult females are severe biters and were found inside houses constantly. This mosquito breeds in a variety of places, most commonly about inhabitations. The eggs and larvae were taken from numerous artificial containers.

Life History. The eggs are small, triangular rafts, slightly larger and more slender than the rafts of *Culex tarsalis* Coq., and were found on floating leaves. The eggs hatch in 24 hours. Usually the length of the larval period is from five to seven days, but some larvae which were reared in the laboratory persisted for 14 days. The length of the pupal period is from two to three days.

This species was numerous in the localities in which it was found, and has been collected in the following localities: Manhattan, September 23, 1936; Riley county, October 30, 1936; Shawnee county, October 30, 1936. This species was not reported as occurring in Kansas by Dyar (1922).

Culex apicalis (Adams)

A small, black mosquito, easily distinguished from other species by the distinctive, apical, narrow white bands on each segment of the abdomen.

Distribution. This species, which appears to be unimportant, was collected in Manhattan in the months of May and October by R. C. Smith. It was not reported by Dyar as occurring in Kansas.

Culex pipiens (Linn.)

A small reddish-brown mosquito with light markings.

Habitat and Habits. This is a pestiferous species, and was found living in the same places in which *Culex territans* (Walk.), *Aedes vexans* (Meig.), and *Theobaldia inornata* (Will.) were found. It has been collected as early as April and May and as late as October, but in 1936 during this study this species was found in the late summer and fall months only.

Life History. The eggs are laid in slender, oblong, boatshaped rafts on the surface of the water. All the eggs that were found hatched in 24 hours or overnight. The length of the larval period is eight days, and the pupal period three days.

Distribution. This is a far eastern species and was not reported by Dyar (1922) as occurring in Kansas. It occurred in large numbers in the localities in which it was found. This mosquito was found in the following places: Clay county, September 24, 1936; Riley county, September, 1936, and October, 1938 (M. West); Douglas county, September 30, 1933 (Hobart M. Smith).

Culex quinquefasciatus (Say)

This mosquito resembles *Culex pipiens* Linn. except that the white abdominal bands are separated from the lateral spots.

Habitat and Habits. Labels of specimens collected by E. S. Tucker at Lawrence, now in the Kansas University collection, are dated July. According to Matheson and Dyar, the habits of this species are much like those of *Culex pipiens* (Linn.).

Megarhinus septentrionalis (D. & K.)

This is a purple and metallic green mosquito which can be distinguished from all other mosquitoes in Kansas by its size and brilliant coloration.

Distribution. A single specimen collected by R. H. Beamer on October 4, 1923, in Douglas county, is in the Kansas University collection.

This is the first time this species has been reported as occurring in Kansas.

Psorophora ciliata (Fab.)

This is the most common, large mosquito in Kansas. It can be distinguished from others by the characteristic, close-set scales on the appendages.

Habitat and Habits. The adults of this species have been collected during the summer and fall months. The adult female is a vicious biter, but it is in part beneficial, because of the predacious habit of the larvae upon the larvae of other mosquitoes.

Distribution. This species is widely distributed in Kansas. Dyar (1922) listed it as occurring in Manhattan only. Specimens from the following localities were seen: Medora, Sand Hills, June 25, 1923 (C. Bare); Arcola, July 20, 1929 (R. H. Painter); Atchison county, July 17, 1924 (R. H. Beamer); Dickinson county, June 16, 1923 (W. B. Whitlow); Leavenworth county, June 25, 1924 (E. P. Breakey); Chautauqua county (R. H. Beamer); Riley county, September (F. M. Marlatt), May 5, 1937 (N. A. DeMoss); Douglas county, October 10, 1935 (Hobart M. Smith); Rush county, July 28, 1912 (F. X. Williams).

Psorophora columbiae (D. & K.)

This is another of the large mosquitoes, but it is smaller than *Psorophora ciliata* (Fab.). The color is uniform blackish brown, with light markings.

Habitat and Habits. Only the adults of this species have been found in Kansas and were collected in June. Specimens were seen from the following localities: Lyons county, June 6, 1923 (R. H. Beamer); Douglas county, (F. H. Snow); Linn county, 1915 (R. H. Beamer); Bourbon county, 1915 (R. H. Beamer).

This species is reported as occurring in Kansas for the first time.

Psorophora cyanescens (Coq.)

A rather large, purple mosquito with characteristic, bright yellow femora.

Habitat and Habits. Only the adults were collected in July, and August.

This species was reported by Dyar from Wellington. Specimens were seen from the following localities: Dickinson county, July 16, 1923 (W. B. Whitlow); Sand Dunes, Medora, July 20, 1934 (R. H. Painter); Manhattan, July 14, 1936; Piper, July 17, 1935 (R. L. Parker).

Psorophora horrida D. & K.

A rather large, purple and black mosquito, resembling *Psorophora cyanescens* (Coq.).

Habitat and Habits. The adults only of this species were collected in July and October.

Distribution. This is the first time that this species has been reported as occurring in Kansas. Specimens were seen from the following localities: Atchison county, July 11, 1924 (R. H. Beamer); Manhattan, October 8, 1933.

Psorophora signipennis (Coq.)

A medium-sized, stout, white-spotted, yellowish black mosquito with black spotted wings.

Habitat and Habits. Only the adults of this species were collected in July.

Distribution. This species was reported by Dyar as occurring in Montana, Texas, New Mexico and Arizona only. It is not a rare species in Kansas, but is reported in the state for the first time. Specimens from the following localities were seen: Doniphan county, July 16, 1924 (W. B. Whitlow); Dickinson county, July 7, 1916 (W. B. Whitlow); Saline county, July 13, 1923 (L. C. Woodruff); Hodgeman county, July 17-25, 1917.

SUMMARY

The specimens used for this study were obtained from the collections of Kansas University and Kansas State College and by collections made by the author or some member of the department of entomology. About 600 specimens were received from Kansas University, 200 from Kansas State College and 500 from the collections made during the study.

The adults and immature stages of mosquitoes were collected during this study in ten counties. The immature stages were reared to adults in mason jars covered with cheesecloth. The adults were sent to Dr. Alan Stone of the United States National Museum for identification.

During the present study, 18 species of mosquitoes were found to occur in Kansas, 11 of which are pestiferous, 3 malarial, and 5 are of no known economic importance.

There were added 8 new county records and 10 new state records of distribution. Judging by collections, the most common species throughout the state are as follows: *Psorophora ciliata* (Fab.), *Anopheles punctipennis* (Say), *Aedes vexans* (Meig.), *Aedes nigromaculis* (Ludl.).

Anopheles punctipennis (Say) is the most common malarial mosquito. *Culex tarsalis* Coq. and *Culex territans* Walk., are the most common species in Riley county.

During the time this work was done, all immature stages found, occurred in artificial containers, which may or may not be the normal breeding places for the particular species of mosquito. Streams, ponds and other bodies of water, which are normally ideal breeding places for certain species of mosquitoes, were free from mosquitoes of any species.

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Notes on Type Specimens and Descriptions of New North American Bombyliidae [1]

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The notes which follow are partly the result of a trip taken December 2, 1932, to January 15, 1933, for a study of the types of Bombyliidae existing in eastern museums.[2] During this study, the types or cotype series of 354 species of Bombyliidae were studied and many compared with specimens in the author's collection. Specimens compared with types and considered conspecific have been designated homotypes or metatypes for convenience in recording and study.

The types of the following species could not be located and apparently are lost: *Villa arenosa* (Coq.), *V. catulina* (Coq.), *V. nugator pallida* (Coq.), *V. otiosa* (Coq.) (= *selene* O. S.), *V. plagosa* (Coq.), *V. tegminipennis sackenii* (Coq.), *V. sodom* (Will.), *Paracosmus insolens* (Coq.), and *Lordotus puella* (Will.). A number of interesting facts have developed from this study. For instance, among the species of *Exoprosopinae* described by Osten Sacken, the types seen usually proved to be of the sex opposite to that stated in the description. The difference in appearance of the sexes in this subfamily is just enough to render identification from these descriptions somewhat uncertain. Among the more difficult groups of species in *Aphoebantus* particularly, more than one species, appears to be represented in some of the type series. In this genus extensive collections and careful study will be necessary in order to associate the sexes of species correctly and to distinguish species.

In the last ten years the author has made more than sixteen hundred different specific identifications, including many specimens in a number of collections.[3] These various series, together with the author's own collection and the study of the types have formed the bases for the notes on variation, comparison of related species, additional descriptions, and keys which follow. In this paper are notes on species of all the North American genera belonging to *Bombyliinae* and *Cytherinae* except *Anastoechus* and *Systoechus*. Species of

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these later genera are being reared in connection with a study of Bombyliidae which feed in grasshopper egg pods, and it is hoped that a study of the immature stages may aid in the classification of the adults. These two genera, as well as those in other subfamilies, will be treated in later papers.

In recording the distribution, the data have been given by states for the common species and those with wide distribution, and in detail for rarer species or those recorded here for the first time since their original description. Detailed distribution records of the commoner species are on file with the author's collection.

The types of new species described below, unless otherwise indicated, are in the collection of the author.

Genus Bombylius L. (Johnson, 1907)

The key given below contains all the North American species known to me occurring east of the Rocky Mountains. *Bombylius helvus* Wied. and *Bombylius clio* Will. have not been identified among the material available for study and are not included in the list. The species from the west which include *B. albicapillus albicapillus* Lw., *albicapillus diegoensis* Painter, *aurifer aurifer* O. S., *aurifer pendens* Cole, *cachinnans* O. S., *cinereus* Bigot, *facialis* Cress., *flavipilosa* Cole, *lancifer* O. S., *laticeps* Bigot, *metopium* O. S. and *silvus* Cole, are in some cases insufficiently known to me to permit the making of a satisfactory key. However, notes on some of these species are included below. An attempt has been made to study the variation within species and to use characters which will be diagnostic. This study has been facilitated by fine series of well-preserved specimens, collected or furnished for study by Mr. F. S. Blanton and Mr. P. W. Fattig. In some species of *Bombylius* the sexes differ in appearance, sometimes one sex will be more easily identified than the other. It is thus highly desirable to have series containing both sexes represented by unrubbed specimens. Of the other species of *Bombylius* listed in Aldrich's catalogue, *bicolor* Lw. is unknown to me; *aequalis* Fabr. and *plumipes* Drury are probably unrecognizable; *haemorrhoicus* Lw., *recurvus* Coq., and *semirufus* Lw. belong to *Heterostylum;* and *albopenicillatus* Big., *ater* Coq., *dolorosus* Will., and *syndesmus* Coq. belong in *Parabombylius*.

Key to the Eastern Species of Bombylius

PAGE

1. Wings with the anterior half brown or blackish with a sinuous and sharply defined posterior margin .... *major* 272
   Wings with the basal portion and spots in the hyaline area brown and well defined..2
   Wings hyaline *or* with brown or blackish brown basal area which is more or less gradually evanescent posteriorly.. 4
2. Wings with the spots more or less coalescent and forming three quite distinct oblique cross bands .... *pulchellus* 274
   Wings with six or seven spots on the hyaline portion......................... 3
3. General color of pile blackish brown; infrasquamal hairs inclined to be whitish except ventrally; more whitish pile and tomentum at apex of abdomen; abundant black pile on sides of abdominal segments two, three, and four....*pygmaeus canadensis* 274
   General color of pile reddish brown; infrasquamal hairs yellowish brown; less whitish pile and tomentum at apex of abdomen; small tufts of black pile on sides of abdominal segments two, three and four...................*pygmaeus pygmaeus* 274
4. Pile of face predominantly gray, yellow or white............................ 5
   Pile of face predominantly black.. 10

PAGE

5. Pile of face and body entirely bright orange yellow, legs yellow, in female wings hyaline; in male wings brown at base, much more black pile on head, tip of abdomen paler yellow pilose..*io* 272
Pile of body gray, more or less mixed with black........................... 6
6. Female, wings hyaline except for spot in cell R, face and front with shining white pile and scales, a few black hairs below antennae, a few long black hairs at apices of segments of abdomen, abdomen otherwise uniformly gray tomentose and sparse gray pilose; basal half of femora brown, apices yellowish (male unknown)..*ravus* 274
Wings more or less smoky at base in both sexes........................... 7
7. Face provided with black pile... 8
Face lacking black pile.. 9
8. (Male only) Wings pale, smoky at base, few or no black pile on dorsum or sides of abdomen, no black pile on thorax..............................*eboreus* 270
Wings of both sexes dark brown at base; male with black pile in front of wings and in both sexes with bunches on sides of abdominal segments two and three *austini* —
9. (Female only) Wings almost hyaline, dorsum of thorax entirely yellow or white pilose, only one row of black bristles across dorsum of abdominal segments and two or three rows at sides of segments two and three.................*eboreus* 270
Wings in both sexes dark at base, but lighter in female; posterior part of dorsum of thorax brown or black pilose; bunches of black bristles on each side of abdominal segments two and three, and in female two rows of black bristles across dorsum of segments two and three...*incanus* 272
10. Mid- and usually fore femora with one or two short bristles at apex above...*varius* 275
Only hairs on mid- and fore femora...................................... 11
11. More than 10 mm. in length, mostly bright orange pilose species............... 12
Less than 10 mm in body length not including antennae and proboscis.......... 13
12. Wings more or less smoky throughout, dark brown at base; pile entirely yollow or orange above on abdomen, brownish to black on venter.................*validus* 275
Wings brown at base, at tips and outer half hyaline, pile yellow or orange above with whitish spots on each side near apex of abdomen, pale beneath; in male with tufts of black hair on each side and a few hairs across dorsum of abdominal segments two and three...*texanus* 275
13. Proboscis much longer than head, thorax, and abdomen combined...........*azalae* 270
Proboscis little if any longer than body.................................. 14
14. Males 15
Females 20
15. *Males:* Abdomen with single row of long black hairs at apices of some segments or without black hairs.. 16
Abdomen with bunches of black hairs on the sides........................... 18
16. Pile of base of wings mostly yellow, brown of wings in males not extending beyond r-m cross vein, wings in female hyaline....................................*io* 272
Pile of base of wings black, brown of wings in both sexes extending along costal margin beyond r-m cross vein.. 17
17. Practically devoid of black hair except on head; face brown..............*medorae* 273
With few black hairs on abdomen and sometimes before base of wing; face black, femora frequently black at base, sometimes wholly yellow............*mexicanus* 274
18. Ground color brownish black with appressed curly scales on the thoracic dorsum, face black, opaque; wings with hyaline part smoky, black hairs less abundant on abdomen ....*fraudulentus* 271
Ground color bluish black without scales on thoracic dorsum, coxae sometimes with black hairs; face brown, shining; wing with hyaline part clear (*fulvibasis*).... 19
19. Brown of wings extends to tip of R_2: much black hair before wings and on coaxae *f. fulvibasis* 271
Less black hair before wings and on coxae; brown of wings extends about to tip of Sc. ....*f. atriceps* 272
20. *Females:* Face and upper half of front black and shining, separated by a rectangular pollinose area at the base of the antennae.........................*mexicanus* 274
At least the face not shining black.. 21
21. Few black hairs except on head.......................................*medorae* 273
Many black hairs on abdomen.. 22

PAGE

22. White tomentose spots on the abdomen usually in the center of segments three to six and also on each side of one, three, four, and five, remaining tomentum golden. Posterior border of wing smoky hyaline, darker brown on anterior border .... *fraudulentus* 271
    No conspicuous white tomentose spots; hyaline and black portion of wing distinctly separated (*fulvibasis*).. 23
23. Brown of wings extends about to tip of subcosta, tomentum of abdominal dorsum golden, pile of coxae white.. *f. atriceps* 272
    Brown of wings extends about to tip of R_3, tomentum of abdominal dorsum yellow, pile of coxae sometimes black.. *f. fulvibasis* 271

Bombylius azalae Shannon (1916)

Except for its long proboscis, which is characteristic of both sexes, the male of this species is much like *Bombylius f. fulvibasis* Macq. The female, however, is much different with its contrasting spots and tufts of white, black, and yellow pile and tomentum. In addition to the type specimens in the National Museum, specimens have been seen from the following localities: 1 ♂ Kingston, N. C., April 18, 1925 (C. S. Brimley); 1 ♂ Raleigh, N. C., April 30, 1925 (T. B. Mitchell), on azalea; 2 ♀ Atlanta, Ga., April 20, 1927, April 28, 1937; 2 ♂ 1 ♀ Georgia (Coll. O. S.).

Bombylius eboreus n. sp.

Male. Ground color grayish black, oral margins, tibiae, base of tarsae and tips of femora light brown. Head and occiput white pilose and tomentose, the former especially dense about the mouth; a patch of white scales on either side of the antennae below which are a few black hairs. Basal joints of antennae clothed with black hairs and a few white ones beneath; a few black hairs on the ocelli. Proboscis somewhat longer than head and thorax. Antennae of the usual type, third joint considerably longer than the basal two together.

Pile of thorax and abdomen ivory to white above, mostly pure white beneath, the pile behind wings and front of halteres pale yellow, a very few black hairs at apices of the abdominal segments of the dorsum and a few more at the sides of segments two and three; appressed white tomentum across the dorsum of segment five, the posterior half of four, and a small patch in the center of two and three. The venter of the abdomen is white pilose on the first three segments, mostly black pilose beyond. Legs white pilose and tomentose with the usual black spines. Halteres with a yellowish knob. Wings hyaline, along the veins very pale smoky, becoming brownish toward the base. The alula and extreme base of the wings opaque, pale brown. Base of costa white pilose. Length of body, 14 mm.; length of proboscis, 7 mm.

Female. Similar to male with paler, almost entirely hyaline wings and yellow legs. Head white pilose and tomentose with the same patch of shining white scales on either side of the antennae and only a few black hairs on the front and ocelli. Antennae almost entirely white pilose; face yellowish in ground color, front grayish black with a band of pale yellow tomentum about half way between the base of the antennae and the ocelli. Pile similar to color in male, but more sparse. Tomentum present, abundant and appressed on thorax, scutellum and abdomen, pale cream-colored, but with a series of white more or less connected spots down the center of the abdomen and on the sides of segments three, four, and five; posterior margins of second and

following segments bearing two rows of long black hairs which are little if any more abundant at the sides of the abdomen. Basal half of abdomen beneath white pilose and tomentose, segments four, five and six brown tomentose and black pilose, the tip again white tomentose and black pilose. Coxae more or less brownish. Length of body, 14 mm.

Holotype. Male, and *allotype*, female, Torrance Co., N. Mex., June 23, elevation 6,000 ft. (R. H. Painter). These were collected within a few miles of Tajique, N. Mex.

Paratypes. One male and thirteen females, same data. An additional badly rubbed specimen with the same data is not designated as a paratype.

This species differs from Bigot's description of *cinereus* in the presence of the silvery white scales beneath the antennae and the black halteres. Bigot had only a male which was seven millimeters in length, hence about half the size of this species. The female differs from *ravus* Lw., in which only that sex is known, in the presence of fewer black hairs on the face and more black hairs on the abdomen. The front of *ravus* is white pilose while it is partially yellow in this species. The abdominal tomentum in *ravus* is of a more uniform color and distribution, while in *eboreus* it is generally pale yellowish with white spots which are denser than the surrounding areas. It differs from the other described species of *Bombylius* which have white facial pile in the presence of the more hyaline wings.

Bombylius fraudulentus Johnson (1907)

This species can be distinguished from *B. fulvibasis atriceps* chiefly by the smaller amount of black pile and the presence of white tomentose stripes and patches on the abdomen, especially in the female. The smoky appearance of the outer margin of wings is apparent only in comparison with other species. The male has some appressed curly yellow scales on the thoracic dorsum. Additional specimens have been seen from New York, New Jersey, Massachusetts and Georgia.

Bombylius fulvibasis fulvibasis Macq.

The male has black pile on the coxae, femora, and in front of wings, and more abundant black pile on the abdomen. Frequently there are black hairs on the pleurae and abdominal venter. The bases of the femora are more or less black. The female usually has a few black hairs on the coxae, and pale yellow pile and tomentum on the abdomen where it is less strongly appressed than in *f. atriceps*. Occasionally there are a few black hairs among the white on the pleurae. Macquart's description of the female "poitrine à fourrure blanche" will apply to most specimens of that sex, and I am retaining his name for this subspecies until the type can be studied. The brown of the wings extends along the front margin of the wing about as far as the tip of R_2. So far many more males than females have been seen. The femora of females are usually entirely yellow.

This subspecies is sometimes difficult to separate from the other and some specimens cannot be definitely placed. The extremes are quite distinct. The extent of the brown on the wings appears to be the most useful character. Specimens at hand are from Long Island and other localities in New York, Connecticut and Wisconsin. Specimens of *fulvibasis* from the latter locality

with the broadly brown wings are both with and without dark pile on the venter. Males of *atriceps* from New Jersey, Oklahoma, Ohio, and Arkansas have the less extended brown on the wings, but possess more or less black pile on the venter.

Bombylius fulvibasis atriceps Loew. (1863)

The cotypes of *atriceps* Lw. and *subvarius* Johns. were compared directly and are practically identical. Johnson's description will serve for the recognition of this form. The male usually has the entire venter, pleurae and coxae white pilose, the metanotum and scutellum yellow pilose. Eastern and specially southeastern males often have more or less black pile on venter and less often in front of the wings. The females differ from the typical form in having darker and more closely appressed golden tomentum on the abdomen. The tomentum is not so bright golden among the eastern specimens. Femora usually yellow. The brown of the wings does not extend as far along the anterior margin as in the case of typical *fulvibasis*. Specimens are at hand from Arkansas, Ohio, Kansas, Nebraska, Iowa, Oklahoma, Michigan, Minnesota, New York, Connecticut and Georgia. Loew recorded it from Florida and Virginia. The Kansas specimens were collected on *Monarda mollis*.

Bombylius incanus Johnson (1907)

This is the only species occurring along the Atlantic seaboard which has a white pilose face, though a number of central and western species have this characteristic. Specimens of this species have been seen from Massachusetts, New York, and New Jersey.

Bombylius io Will.

Four cotype females of this species were seen at the American Museum of Natural History. The species has been collected at Brownwood, Austin, Kingsville, Eddy, Plainview, Uvalde, and Rowena, Texas, from May to August. I have specimens also from Lawton, Oklahoma, Lee county, Arkansas, Atherton, Missouri, Wasta and Okaton, South Dakota, and Kansas. The antennae of many of the females have the basal joints yellow as in the cotypes, others have them brown or blackish. The body pile is a bright orange-yellow. The males, which are always associated with these females, have the basal third of the wings brownish, the antennae, face, front, and ocellar tubercle black pilose. Thus they agree with Williston's description of the male of *B. clio* rather than that of *io*. The males from Uvalde have the face partly yellow pilose and the females have a few black hairs on the face and antennae.

Bombylius major L.

Over 400 specimens of this species from 123 localities have been examined during the last ten years. Fourteen of the different series of specimens were collected in March, 51 in April, 43 in May, 8 in June and 1 in July. The species is distributed over much of the United States. It is known to occur in Northern Europe and Asia, where a number of varieties have been described. The series available from North America show considerable range in the intensity of the yellow color of the pile, the amount of black pile on the sides of the abdomen, and details of wing pattern. So far there appears to be no definite correlation between these characters and the geographic localities from which the specimens come.

A study of a distribution map of the specimens mentioned above shows that most of them come from the neighborhood of colleges or research institutions. This is not surprising considering the early dates on which this species is on the wing. The map shows that *B. major* may be absent from the northern great plains. Specimens have been examined from the following states: Arizona, British Columbia, California, Colorado, Connecticut, Pennsylvainia, District of Columbia, Georgia, Idaho, Illinois, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, New York; Oklahoma, Oregon, Pennsylvania, South Carolina, Texas, Utah, Washington, and Wisconsin.

This species was collected on the flowers of lilac and wild plum in Kansas.

Bombylius medorae n. sp.

This species is similar to *fulvibasis* Macq. and *fraudulentus* Johns., but is practically devoid of black hairs except on the head and has the outer margin and tip of the wing pure hyaline.

Male. Ground color brownish black; legs beyond coxae yellow; tarsi and extreme tips of femora brownish to black; face brown, shining. Head and antennae black pilose, occiput yellowish tomentose; ventral part of head white pilose, a few yellowish hairs on the upper margin of the mouth. Thorax and abdomen yellow pilose, white pilose beneath; metanotum and scutellum sparse yellow tomentose, a sparse white tomentose pattern on the abdomen consisting of a central white stripe with cross bands at the apices of the third, fourth and fifth segments and a suggestion of a similar cross band on segment two; two or three black hairs at the sides of the segments two and three; venter of abdomen and legs white tomentose, the latter with black spines. Wings hyaline, brown at the base with this color extending about to the apex of R_1. Length of body, 8 mm.; length of proboscis, 4 mm.

Female. Similar to the male, a few more yellow hairs on the face. Front sparse yellow tomentose and black pilose, a shining black more or less trapazoidal area in front of the ocelli. The tomentum of thorax and abdomen much denser than in male, entirely covering the abdomen, golden yellow, but with paler, almost white, areas on the sides of segments three, four, and five. The apices of the segments bear the usual stiff hairs, most of these are yellow, but at irregular intervals among the yellow, a few black ones appear. The same remark would apply to the hairs along the sides of the abdomen. Venter white pilose and tomentose. Legs yellow with white tomentum and black spines. The brown area of the wings is somewhat more restricted than the male.

Holotype. Male, and *allotype*, female, sand dunes, Medora, Kan., July 21, 1931 (R. H. Painter) in the collection of the author.

Paratypes. Sand dunes, Medora, Kan., 32 ♂ 44 ♀ July 21, 1931; 1 ♂ 4 ♀ July 4; 7 ♀ July 3; 14 ♂ 9 ♀ June 8, 1933 (R. H. Painter); 2 ♂ 2 ♀ June 7, 1933; 1 ♂ 1 ♀ July 21, 1931 (C. W. Sabrosky); and 3 ♂ 3 ♀ Brownwood, Texas, June 1, 1930. The following paratypes are in the University of Kansas collection: 28 ♂ 9 ♀ Clark county, Kansas, June, 1,962 ft. (F. H. Snow); 1 ♂ 2 ♀ Medora, Kan., sand hills, June 25, 1923 (H. Darby); 19 ♂ 15 ♀ Barton county, Kansas, 1,816 ft., June 22, 1912 (X. F. Williams).

This species differs from others in its area in the very small number of black hairs on the abdomen. It appears to be most closely related to *fraudulentus* Johns., differing from that species principally in the amount of black pile on the abdomen. *Fraudulentus,* however, is known so far only from east of the Appalachian Mountains. This species hence appears much farther west. It has frequently been present in considerable numbers on the flowers of *Asclepias tuberosa.* The sand dunes southwest of Medora, Kan., have been a favorite collecting grounds for Kansas entomologists. This insect is conspicuous and sometimes very abundant at the time it is on the wing.

Bombylius medorae is similar to *facialis,* but differs in the smaller size and paler wings. The males of *medorae* have yellow femora which are white pilose while those of *facialis* have femora dark at the base and partly black pilose. The females of *medorae* have shorter pile and denser tomentum than that sex of *facialis.* Also the center of the abdominal tomentum in *facialis* is white while the same area in *medorae* is only slightly lighter.

Bombylius mexicanus Wied.

Next to *varius* and *validus* this is the largest species found in its area of distribution. Specimens have been seen from New York, Pennsylvania, New Jersey, Quebec, British Columbia, Georgia, Virginia, Maryland, North Carolina, and Florida, Mississippi, Michigan and Minnesota.

Bombylius pulchellus Loew.

The cotype series of two males and one female have been seen, as well as other specimens from New Jersey, Connecticut, Pennsylvania, Ohio, Kansas, Iowa, Wisconsin, Long Island, and other New York localities, Illinois, Maine, Minnesota, and New Jersey. Manhattan, Kan., is the most western record for this species.

Bombylius pygmaeus pygmaeus Fab.

The typical form is distinguished from *canadensis* by the characters given in the key. Specimens have been seen from Long Island and other New York localities, Massachusetts, Maryland, Georgia, and New Jersey. Four males from Havana, Ill., in the University of Illinois collection represent its farthest western distribution.

Bombylius pygmaeus canadensis Curran (1933)

The type of *canadensis* has not been seen, but specimens from Gallatin county, Montana, Door county, Wisconsin, Midland and Kalkaska counties, Michigan, and Chamber's Lake, Colorado, agree with the description. This is evidently a boreal form which extends south along the Rocky Mountains. A female, Chelsea, Que., May 30, 1923 (A. Richardson), is intermediate in many respects between *canadensis* and *pygmaeus* so that this former form probably should be considered a subspecies.

Bombylius ravus Lw.

A female from Austin, Texas, March 25, 1921, agrees with Loew's type female. This species is similar to *incanus* Johns. The wings are entirely hyaline, and there are only a few long, black hairs along the posterior borders of the abdominal segments. Face soft white pilose below, black pilose above,

basal joints of antennae with white hairs above, black below. Front entirely white tomentose and pilose with a few black hairs on the ocellar tubercle. A very few long black hairs on the posterior part of the thorax, the scutellum and the posterior margins of the second and following segments. The vesture of the rest of the body is a uniform grayish white, the abdomen being without any conspicuous patches of lighter colored tomentum. Bases of the femora dark brown.

Bombylius texanus Painter (1933)

Since its description, additional specimens of this species have been seen from Austin and Brownwood, Texas; Bryant, Idabel, and Stillwater, Oklahoma; Osage, Chase, Chautauqua, and Montgomery counties, Kansas. In some of these specimens the pile is somewhat grayish. The size of this species (12-15 mm.) will distinguish it from others in its area of distribution.

Bombylius validus Loew

There are two male cotypes in good condition in the Museum of Comparative Zoölogy. This species is apparently rare and is distinguished by its large size, by the smoky wings, and almost uniformly yellow pilose body. Specimens have been seen from: 1 Owatonna, Minn., June 25, 1923 (Keene); 1 Norman county, Minnesota, June 24 (A. A. Nichol); 1 Urbana, Ill., June 24, 1904 (Hart and Kegley); 1 Crawford county, Mich., July 14, 1932 (Driesbach).

Bombylius varius Fab.

This species is the only North American species with one or two short spines at the apex of the middle and fore femora. It carries more black pile on the abdomen than most species. In some, but not all, of the specimens from Georgia much of the posterior part of the thorax is also black pilose. The abdomen of the female has spots of white scales in the center and on each side. Specimens have been seen from New Jersey, Connecticut, New York, Georgia and Missouri, and were taken in June and July.

The Western Species of *Bombylius*

In addition to *major, lancifer* and *albicapillus* appear to be the only common species, although some of the other western species appear to be widespread. A number of individual specimens and a few series which may represent new species are at hand, but the writer prefers to leave these undescribed until more is known of the variation and distribution of described species rather than make the studies of later workers more difficult by describing these now from insufficient material. *Bombylius laticeps* and *cinereus* have not been identified for certain among the specimens so far seen.

Bombylius duncani n. sp.

Male. Ground color bluish black, including the legs. Face grayish black, clothed with fairly dense white pile and long black hairs; front hidden beneath shining white scales, occiput and ventral parts of head long white pilose. Antennae with the basal joints long black pilose, a few black hairs on ocelli. Thorax white pilose with a few black hairs on the posterior part of the metanotum and long black hair in front of the wings. Abdomen clothed with long black and white hairs, the former are especially abundant on the sides of

the abdomen from the base of the second segment to the apex of the fourth segment; sparse white tomentum in the center of the third segment and occupying most of the remaining segments. Venter of abdomen and thorax white tomentose and mostly white pilose, a few black hairs at the tip of the abdomen. Legs white tomentose, the pile long and white on the coxae and at the base of the femora, black toward the distal half of the femora. Wings black on the anterior half, the center of the cells somewhat lighter; the dark area occupies most of cell R_1, the basal half of R_3, the basal third of R_5, the basal third of the discal cell and of Cu_1; the parts of the wings toward the body from these areas are mostly dark, the dark color follows out along the veins and even the hyaline parts appear somewhat smoky. Halteres brownish-black. Length of body, 8 mm.; length of proboscis, 4 mm.

Female. Similar to male, but with somewhat more tomentum especially on the abdomen. Face with somewhat less white pile above the mouth, patches of silvery scales on each side of the antennae, front sparsely black pilose and yellow tomentose, a more conspicuous patch of yellow tomentum at the base of costa. The abdomen of the allotype is somewhat rubbed, but apparently had more yellowish tomentum than in the case of the male. Similar patches of white pile on the sides of the first, second, and fifth segments, the sides of the third and fourth almost entirely black pilose.

This species differs from many others in the genus in that both sexes have entirely black legs of which the tibiae are only slightly lighter in color; and in having the lateral margins of segments three and four entirely black pilose without intermixture of tufts of white pile. This species is also characterized by peculiarly long hairs scattered about on the body. The halteres of both sexes are brownish black.

Holotype. Male, base of Pinal Mts., Ariz., April (D. K. Duncan).

Allotype. Female, Tempe, Ariz., April (D. K. Duncan).

Paratype. Males, one each from base of Pinal Mts., Arizona, April; Tempe, Ariz., April; and Tucson, Ariz. (D. K. Duncan); and Jacumba, Cal., April 26, 1935 (G. P. Englehardt).

This species is named for Mr. D. K. Duncan, from whom I have received many interesting and rare beeflies.

This species appears most closely related to *metopium* O. S., but lacks the yellow tomentum and pile present in that species. Moreover, in *metopium* the patch of black hair in front of the wings extends on to the occiput, the light colored pile of the face is very sparse, and there are darker spots on the cross veins of the wings which are not at all evident in *duncani*. In *duncani* the pile, especially on the sides of the abdomen, is longer and sparser.

Bombylius facialis Cress. (1919)

Cresson was apparently correct in the association of the male and female of this species. It is related to *lancifer* O. S. and *fulvibasis* Macq. in the appearance and structure of the face. The pale yellow pile of the thorax and abdomen with only a few black hairs on some segments of the latter will serve to distinguish it from most of its relatives. In the male the bases of the femora are black, and there are bands of sparse tomentum on the apices of the segments. In the female the femora are yellow, and there is a white stripe down the center of the abdomen, with patches of white tomentum on each side of segments three, four, five, and six. A semitrapezoidal area in front of the

ocelli is black and shining. *Bombylius mexicanus* has this same type of area, but the face of the female of *mexicanus* is black instead of brown. Specimens have been seen from:

Colorado: 1 from Boulder Co., June 8, 1936 (Chas. H. Hicks); 2 from A. S. U. C. Lodge, near Boulder, 7,700 ft. elevation, June 15, 1933 (James); 1 near Ward, June 2-9, 1933 (H. G. and H. E. Rodeck); 1 from Poncha Pass, June 20 (Chas. Wagner); and 12 from Boulder, June 2, 15, 18, 1933, (James).

New Mexico: 1 from Trout Springs, N. Mex., May 24, (Cockerell).

Arizona: 1♀ from Rincon Mts., Ariz., altitude 4,000 ft. April 9, 1925; and 1♂ from Williams, Ariz., altitude 7,000 ft., June 14, 1925 (A. A. Nichol).

Bombylius flavipilosa Cole (1923)

This is the smallest North American species of Bombylius so far known. The species was described from two females. There are at hand four females and two males from Tucson, Ariz., August 9, 1930; 1 female, Wilcox, Ariz., August 11, 1930 (T. F. Winburn and R. H. Painter); and 1 male, Steins, N. Mex., August 8, 1932 (Painter). The writer is indebted to Dr. Maurice T. James for comparison of one of the females from Tucson with the type in the Museum of the Academy of Sciences, California. The wings of the female are almost hyaline, the vein at the base of 2d M_2 varies in length. Some of the females are almost totally lacking the black hairs mentioned in the description as being present on the mesonotum and abdomen. Only a very few black hairs are present on the posterior margins of the latter.

The male may be described as follows: Ground color grayish black, oral margins, legs except tips of femora and tarsi yellow, margins of ventral abdominal segments and genitalia brownish. Head clothed with yellow pile; black hairs on the first two joints of antennae, ocellar triangle, and sides of face; a few yellow scales on the front and each side of the antennae. Form of antennae similar to female. (See Cole 1923, fig. 6.) Pile of body almost entirely pale yellow, occasionally a few black hairs on the dorsum of the abdomen, a very few appressed yellow hairs on the dorsum of the last two abdominal segments. Spines of legs black. Wing hyaline, the base of the wing to about as far as cell R pale smoky, the margin of this area indistinct. Halteres with white knobs. Length of body, 7 mm.; length of proboscis, 3 mm.

Androtype. Male, Steins, N. Mex., August 8, 1932, (R. H. Painter).

Parallotypes. Two males, Tucson, Ariz., August 9, 1930 (T. F. Winburn and R. H. Painter).

These specimens were collected in company with *Parabombylius syndesmus, P. maculosus* and *P. subflavus*. The male of *B. flavipilosa* differs from that of *B. io* in the presence of much more abundant yellow pile on the face, the yellow scales on the front, the paler wings, and the smaller size.

GENUS PARABOMBYLIUS Will. Painter (1926), Curran (1930)

Parabombylius ater (Coq.)

The author collected this species at Manhattan, Kansas, May 27, June 6, 7, 24, and September 13. Some of these specimens were apparently ovipositing in the openings in nests of the solitary bee, *Diadasia afflicta* Cresson (Det. Cockerell). I have also seen specimens from Port Lavaca, Texas, Atherton, Missouri, Fayetteville, Arkansas, and Douglas county, Kansas.

Parabombylius syndesmus (Coq.)

The types in the National Museum came from California. I have records for additional specimens as follows: 1 ♀ Sacaton, Ariz., August 8; 1 ♂ 1 ♀ Tucson, Ariz., August 9; 1 ♀ Wilcox, Ariz., August 11, 1930 (Winburn, Painter); 1 ♀ Palatox, Texas, July 30 (H. M. Smith). There is considerable variation in the extent of the black ground color of the abdomen.

Parabombylius nigrofemoratus new name

Parabombylius vittatus Curran (1930) nec. Painter (1926)

In the type female the abdomen and head appear to be greasy and the color of the tomentum is now obscured. The chief differences from *P. maculosus* Painter are, femora entirely black and pile on pleurae and abdominal venter black. Specimens which may be the males have been collected at Sells, and Tubac, Ariz. (Winburn and Painter).

Parabombylius maculosus Painter

Sixty-eight females of this species have been collected from near Tucson and Wilcox, Ariz., August 9 and 11, 1930 (Painter and Winburn); 1 ♀ Tucson, Ariz., Aug. 16, 1935, (E. I. Beamer); 2 ♀ Ajo, Ariz., July 23, 1938, (R. H. Beamer) Kansas University; and 1 ♀ Globe, Ariz., August, (D. K. Duncan). In the type female, the abdomen is rubbed. In these other specimens the patches of white scales are along the apex of segment one, and with spots in the center of the apex of the second and following segments and on each side of the margin of the third and following segments. The femora sometimes are completely yellow, in other specimens the basal half is more or less black. The amount of black pile on the second abdominal segment is variable; sometimes there is a little on the third segment. The central white thoracic stripes are usually broken near the caudal ends.

Male. Ground color black, distal fourth of femora and tibiae yellow. Pile long and pale yellow on body and occiput, black on face, front, ocellar tubercle, antennae, coxae and as tufts on each side of segments two and three. Small patches of white scales on each side of the antennae, on the occiput opposite the humeri, two near the center of the thorax and another near the base of the scutellum (forming the apex of a triangle), along the apex of the first abdominal segment, the center of the apex of the second and following segments and long white scalelike hairs on the sides of the fourth and following segments. Wings hyaline, extreme base yellowish, setae of legs black. Pile on antennae long. (Pl. 2.)

Androtype. Male, Tucson, Ariz., August 9, 1930 (T. F. Winburn, R. H. Painter).

Parallotypes. Six males same data; one male, Sacaton, Ariz., August 8 and three, Wilcox, Ariz., August 11, 1930, all collected by Winburn and Painter.

Parabombylius subflavus Painter (1926)

The type male is in the United States National Museum (No. 40340). Other males have been collected from Wilcox, Ariz., August 11, Sacaton, Ariz., August 8, 1930 (Winburn, Painter), and Tubac, Ariz., August 5, 1932 (Painter). The female may be described as follows:

Body black to brown, first two segments of antennae (Pl. 2) and legs

except tarsi and coxae yellow. Pile and tomentum light yellow on thorax and first abdominal segment; golden yellow on scutellum, occiput, face, front, antennae and much of the abdomen. A few black hairs on the face, ocellar tubercle and sides of abdominal segment two. Brilliant patches of white scales on either side of antennae, on occiput opposite humeri, margin of first abdominal segment, center of apex of second and following segments. Setae of legs black. Wings hyaline, cell R slightly smoky. Length, 6 mm.

Allotype. Female, Tubac, Ariz., August 5, 1932 (R. H. Painter).

Two parallotypes same data; one other, Tucson, Ariz., August 9, 1930 (Winburn & Painter). In some specimens the margins of the abdominal segments and venter are reddish. This species lacks the white patches and stripes on the thorax. The golden tomentum of the abdomen is appressed as in *maculosus*.

Parabombylius pulcher Painter (1926)

A drawing of the antennae of the type female is given to facilitate identification (Pl. 2). A number of dark specimens of *Parabombylius*, both males and females are at hand, which show a considerable range of variation; the exact relationship of these specimens with this species and with *dolorosus* (Will.) and *albopenicillatus* (Bigot) is not yet evident and will have to await a study of a larger series.

Parabombylius vittatus Painter (1926)

Known only from the type female. This species differs from *maculosus* and *subflavus* in having the face and antennae long pilose (Pl. 2) as well as in the color of the tomentum and pile.

Genus HETEROSTYLUM Macq., Painter, 1930

Heterostylum haemorrhoicus (Lw.) (New combination)

Bombylius haemorrhoicus Loew.

This species is known only from the type male in the Museum of Comparative Zoölogy. It is like *H. semirufum* (Lw.) except that the red pile is confined to abdominal segment five and the following segments and extends all across the abdomen.

Heterostylum englehardti Painter

Two additional female specimens, Phoenix, Ariz., April 18, 19, 1931 (E. M. Painter), have the tips of some hairs dark brown on segments three, four, and six. The species is easily distinguished from light-colored specimens of *H. robustum* (O. S.) (Pl. 2) by the shape of the third antennal joint. Drawing of antenna is given on Plate 2.

Heterostylum novum (Will.) (new combination)

Triplasius novus Williston 1893

Bombylius recurvus Coquillett 1902

A male cotype of *B. recurvus* (Pl. 2) from the United States National Museum has been compared directly with the male type of *T. novus* in the Snow collection. They are identical except that the former lacks a part of the cross vein in the radial area where it is complete in *T. novus*. Both speci-

mens have the incision in the posterior orbits, typical of *Heterostylum*, but the head is somewhat narrower than among the typical species. There is an additional specimen from Kern county, California, in the Snow collection which is of the *recurvus* type. This series of specimens emphasizes the unreliability of the presence or absence of this cross vein in the radial area of Bombyliidae as the sole criterion for the separation of genera. In common with other species of this genus it has two-segmented palpi and short pulvilli. A drawing of the antenna is given on Plate 2. In addition to the type, three males have been seen from Tub Spring, Borego, Cal., March 21, 1935 (Cockerell) and Tempe, Ariz., April, (Duncan), and 1♀ Ray, Ariz., April 26, 1938 (F. H. Parker).

Heterostylum vierecki Cresson (1919)

This species is very similar to *H. novum* (Will.) in respect to the recurved course of R_2. It differs, however, in lacking all trace of the cross vein, in the shape of the antennae (Pl. 2), in the presence of white pile on the antennae, and with more abundant black pile on the abdomen and scutellum, and lighter color of the wings. This species and *H. novum* (Will.) differ somewhat from the other species in this genus in the smaller head and recurved course of R_2. In the former they are approached by *semirufus* Loew and to a less extent by *croceum* Painter. The latter species shows a tendency to develop stumps of cross veins in the radial area of the wing.

Heterostylum deani Painter

One of the paratypes recorded from "Berkley, California" should have been recorded from "Berkeley, Colorado." I have seen only females of this species.

Genus SPARNOPOLIUS Loew

In some species of this genus the first antennal segment is more expanded than in the case of most of the other genera in this subfamily. In this character the structure approaches that of *Conophorus, Aldrichia,* and related genera which have sometimes been placed in a separate subfamily.

Key to Species of Sparnopolius

			PAGE
1.	Abdomen entirely yellow pilose and tomentose	2	
	Abdomen with at least a few long black hairs	4	
2.	Pile of body pale greenish yellow, dorsum thickly grayish pollinose	*cumatilis*	280
	Pile of body yellow, dorsum black or thinly pollinose	3	
3.	Face shining; usually two submarginal cells	*fulvus*	281
	Face pollinose; usually three submarginal cells	*anomala* n. sp.	281
4.	Male with abundant black pile on last two abdominal segments, female with scattered long black hair on dorsum of abdomen and thorax; Mexican species	*diversus*	281
	Both sexes with a few long black hairs on posterior segments of abdomen	5	
5.	Antennal segments two and three in proportion of 8 to 3, Rocky Mts. species	*coloradensis*	281
	Antennal segments two and three in proportion 5 to 3; the latter broader than the former; Texas species	*brevicornis*	281

Sparnopolius cumatilis Grote

The heavily gray pollinose ground color of the dorsum and peculiar greenish-yellow pile give this species an unusual appearance. It differs from other species in the genus in the abundant yellow tomentum on the front. A draw-

ing of the antenna is found on Plate 1. The four female types are in the collection of the Philadelphia Academy of Natural Sciences. Another female labeled "Col." is in Snow collection. No males have been seen.

Sparnopolius fulvus (Wied.)

This species occurs throughout the eastern half of the United States. It is especially abundant in eastern Kansas on sunflowers in September and October. Specimens of *S. fulvus* have been seen from Arkansas, Colorado, Illinois, Iowa, Kansas, Maryland, Massachusetts, Minnesota, Missouri, Montana, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, and Virginia. It is on the wing mostly in August and September. There are a few records for October, one in July and one in June.

Sparnopolius diversus Will.

Williston described the male from a single specimen. The female which he noted under *S. fulvus* as taken at the same time and place as the type male of *diversus* is undoubtedly the female of *diversus*. Males and females which agree with Williston's descriptions have been seen from District Federal, Mexico, July 10 (L. Conradt). In addition to the characters given in the key the female differs from *fulvus* in having the face pollinose and having longer hairs on the antennae. The hairs are both black and yellow in the *diversus* female, but entirely yellow in the *fulvus* female.

Sparnopolius brevicornis Loew, (1872)

In a series of specimens from Brownwood and Austin, Texas, September and October (R. H. Painter) the relative lengths of the third and second antennal segments were as follows: 5 to 3; 5.3 to 3; 6.5 to 3; 5 to 2.5; 5 to 2.5; 5 to 2. The sexes did not differ constantly in respect to relative length of antennae. The two type females are in the Museum of Comparative Zoölogy.

Sparnopolius coloradensis Grote, (1866)

The principle difference, if not the only one, between this species and the preceding lies in the shape and proportion of the last two antennal segments. In one of the three type specimens the proportion of the third to the second segment was 8 to 3. In a series of specimens of both sexes from LaVeta, September 2 (E. M. Painter), and Manitou Park, August (Snow), Colorado, the proportions were 9 to 4; 8.5 to 3.4; 7.5 to 3; 9 to 4; and 3 specimens 8 to 3. A series of specimens from Colfax county, N. Mex., had the following proportions: 6.5 to 3; 6.5 to 2.5; 7 to 3; 6 to 3; 6.3 to 3; 10 to 4. The last specimen was merely labeled "N. Mex." It is evident that additional specimens from intermediate localities may indicate that *brevicornis* and *coloradensis* are variants of the same species. The male genitalia do not appear to be different. Specimens have also been seen from several localities in Utah, (Maughan, 1935).

Sparnopolius anomala n. sp.

A species that is almost identical with *S. fulvus*, but differs in having three submarginal cells, and a dull gray pollinose rather than shining face.

Male. Ground color black, dull gray pollinose beneath, entirely yellow pilose, including the first two antennal joints (Pl. 1): body and head some-

what paler beneath. Scutellum and abdominal dorsum sparsely, short, curly, yellow tomentose. Face, front and first two antennal segments dull gray pollinose. Femora yellowish white pilose and tomentose, without setae, all tibiae setulose. Wings hyaline, veins yellowish to brown, venation identical with *Sparnopolius fulvus* except for the presence of a vein between R_{2+3} and R_4 (Pl. 1). Length, 8 mm.

Female. Similar to male, the abdomen broader, the pile of the dorsum shorter than in male. Face yellow tomentose and pilose. Antennae more slender than in male.

Type. Male, LaVeta, Colo., September 2 (E. M. Painter).

Allotype. Female, LaVeta, Colo., September 2 (E. M. Painter).

Paratypes. 2 ♂ 1 ♀ same data (in author's collection) 3 ♂ 2 ♀ "Colo." (in United States National Museum).

The generic placing of this species might be open to question. On account of previous experience with the unreliability of the single venational character, the number of submarginal cells, in which this species differs from typical *Sparnopolius,* it has been referred to that genus.

This species differs from those in *Conophorus* in the character of the vesture, and in lacking the uniformly enlarged first antennal segment with the eccentrically placed second segment. In *S. anomala* the first antennal segment in the male appears enlarged at the base when viewed from above, while in the female it is as in *S. fulvus.* This species differs from *Lordotus,* which has three submarginal cells, in the position of the r — m cross vein, which is situated near the base of the discal cell in *S. anomala* and far beyond the middle in *Lordotus.* In addition the females of *Lordotus* have only five abdominal segments normally visible while the remainder form a narrow tubular ovipositor. In *anomala* the abdominal segments are not in this form, but similar to those of other species of *Sparnopolius.*

Genus LORDOTUS Loew

In North America there are thirteen names applied to described species of *Lordotus,* but of these only four were described from both sexes. Since there is often considerable difference in the appearance of the two sexes it has been difficult to associate the two correctly. It is surprising that in only one case have the different sexes been given separate names. The types of all the species have been examined except that of *puella* Will., which is apparently lost. In *pulchrissimus, diversus* and perhaps *zona,* the males are whitish pilose while the females are yellow. In *gibbus* both males and females may be either white or yellow; the distinctions between the sexes in other species are various. In some cases the same sexes of two species may be more alike than the different sexes of the same species. No allotypes have been designated unless there was abundant evidence that the two sexes belong together. No new species have been described unless both sexes were available and had been checked with types or homotypes.

At least four undescribed species or subspecies of *Lordotus* have been studied. They have usually been represented by only a few specimens, usually of one sex. It is believed that the taxonomy of the group will best be served by leaving these undescribed until the two sexes of each species can be correctly associated and the interspecific variation studied.

Key to North American Species of Lordotus

PAGE

1. Wings with gray or brown clouds especially at base of Cu_1, and on r-m cross vein; sometimes clouds are faint 2
   Wings hyaline, costa and base of R occasionally yellowish 5
2. Pile of antennae yellow; length of second antennal segment at base at least 1½ its width 3
   Pile of antennae black, at least above, if the latter, pile of palpi black; second antennal segment little longer than wide 4
3. Central stripe of abdominal tomentum of same color as pile in female, lacking in male .... *gibbus gibbus* 287
   Central stripe of abdominal tomentum and sparse tomentum of thorax silvery in both male and female .... *gibbus striatus* 287
4. Female: Pile of posterior half of 4th abdominal segment black pilose; head, thorax, and abdomen with appressed white woolly hair beneath long straight yellow pile. Pile on upper side of antennae black. (Male unknown) .... *bucerus* 285
   Male and female. Pile entirely light colored except the black or brownish antennal pile, hair of palpi white; smoky spots on base of cells R_4, R_5, M_1, 2nd M_2, Cu_1, and on basal bifurcation of radial sector .... *planus* 289
5. Pile of antennae dark, sometimes short above, lighter below 6
   Pile of antennae yellow or white 7
   Pile of antennae black 10
6. First antennal segment about equal to second. Male with pile of abdomen entirely white, of antennae black to brown above, orange to brown below (for female see couplet 7) (see, also, *puella*) .... *diversus* 285
   First antennal segment about twice as long as second. Pile of antennae short black to yellow above, long and white beneath, pile of abdomen in both sexes with some black or brown pile contrasting with the more abundant white; costa of male denticulate .... *miscella* 289
7. First antennal segment about equal in length to second, yellow in ground color, third broad; pile of breast, abdomen and antennae yellow to orange in female (for male see couplet 6) .... *diversus* 285
   First antennal segment at least 1½ the length of second, black or yellow in ground color; pile of breast white 8
8. Legs black; in female abdomen and thorax with sparse yellow hairs above, tomentum of thick curley white hair, ground color of hind margins of dorsal abdominal segments 2, 3 and 4 yellow; male with long curly tomentum on margins of abdominal segments; male costa not denticulate .... *junceus* 288
   Legs especially tibia and tips of femora more or less yellow; vesture mostly of pile, costa of male except in small specimens denticulate 9
9. Femora of male yellow. (Female unknown) .... *zona* 292
   Femora of male black at base, pile white; in female femora and first two segments of antennae yellow; pile orange; very little tomentum on abdomen .... *pulchrissimus* 290
10. Male, pile of breast and face grayish yellow. (Female unknown) .... *puella* 290
    Pile of breast and front coxae black or dark brown 11
11. Male, pile of abdominal dorsum entirely black or dark brown. (Female unknown) *divisus* 286
    Pile of abdominal dorsum in part white 12
12. Abdominal venter white pilose .... *sororculus* 291
    Abdominal venter black or dark brown pilose 13
13. First antennal segment three times length of 2d; dorsum of abdomen of female white pilose .... *apicula* 283
    First antennal segment 1½ times length of second; dorsum of abdomen of female white pilose on basal half, at apex brown .... *bipartitus* 284

Lordotus apicula Coq.

The type is a single rubbed female; the type locality is Colorado. The last segments of the antenae of the type are lacking. The eight females before me are not in very good condition. As far as ascertainable they agree in the following characters; face, antennae (Pl. 1), palpi, legs, abdominal venter

and much of the pleurae black pilose. Front shining, partly hidden beneath sparse curly tomentum and some stiff hairs, which in one specimen are black as in the type, in another are yellow and in two are partly black, partly yellow. Metanotum brownish opaque in ground color with three lighter stripes, clothed as is the abdomen with yellowish and white pile and curly white tomentum, the latter thicker at the junction of the segments. Wings hyaline, base of costa white pilose; legs black, femora black tomentose. Some of the specimens do not have the tomentum on the abdomen and may not belong to this species.

The females studied are from Stein Mts., Harney county, Oregon, June 24, 1922 (Chamberlin); Burns, Ore., El. 4,150 ft., July 2, 1927, (Scullen); Superior, Ariz., April (Duncan); Phoenix, Ariz., April 18, 1931 (E. M. Painter) "picked up dead"; Tucson Ariz., April 24, 1937 (W. Benedict); 2 Las Cruces, N. Mex., April 4; and 1, Wyoming.

The males which I believe belong to this species are very similar to the male of *bipartitus,* differing in their smaller size (7-10 mm.), black pilose base of costa, the greater extent of the black pile on the pleurae, and the dull brown metanotum with its three lighter stripes. The pile on the scutellum is yellow, elsewhere on the dorsum it is white; the venter, legs, pleurae and head except upper occiput are black pilose. The second antennal segment is about as long as broad, hence shorter than in *bipartitus.* In two specimens the posterior half of the abdomen is white pilose.

The males are from Alamagordo, N. Mex., April 8, 1902, and Globe, Ariz., April (Duncan); Tucson Ariz., April 4, 1937 (W. Benedict); Kern county, Cal.; Borga, Cal., April 3, Deep Canyon, Santa Rosa Mts., Cal., March 8, 1930 (D. G. Hall); Ephriam, Utah, June 8, 1938 (Knowlton, Harmston).

This species has been recorded from Guaymas, Lower California (Cole) and I have seen specimens from Vernon, Utah (Knowlton).

Lordotus bipartitus n. sp.

Venter and head largely black or brown pilose, dorsum whitish pilose, in female the last three segments of abdomen black or brownish pilose; wings hyaline. Length, 10-13 mm.

Male. Ground color of metanotum and abdomen black with bluish reflections on the dorsum and grayish brown beneath. Head, antennae and palpi black pilose, occiput above pale yellowish pilose. First antennal segment about 1½ times the length of the second, third about as long as the first two together (Pl. 1). Proboscis about three times the length of antennae. Upper half of the eyes with larger facets. Thorax whitish or very pale yellow pilose above, mesopleura whitish pilose above, black pilose below, mesosternum with a few white hairs above and sparse black ones below, pteropleura and metasternum bare, hypopleura brownish pilose, a small tuft of black hair on the upper part of the metapleurum, coxae and legs black pilose, the latter black tomentose. Abdomen whitish pilose above, black pilose below; golden brown pilose at the junction of the two colors; the last two segments and genitalia white pilose. Wings hyaline, costa and before arculus yellowish, veins brown, alulal fringe of white pile, tip of R_2 rather more recurved than usual. Costa without teeth, but with minute black setulae, base of costal cell and costa white pilose. Halteres pale, knobs white.

Female. Similar to male, except as noted below. The dark pile of face antennae, coxae, and pleurae golden brown to black. Front and occiput except below, clothed with stiff pale yellow hairs and short curly white ones. Metanotum, scutellum and first two segments of the abdomen clothed with similar vesture. Entire pleurae except the bare pteropleura and metasternum clothed with dark yellow to white pile. Abdominal venter and last three segments of dorsum dark brown pilose, a few curly scales on the center of the latter. The ground color of these last three segments is brown while that of the remainder of the body and head is grayish.

Type male, *allotype* female and 11♂ 30♀ paratypes Steins, N. Mex., August 8, 1932 (R. H., E. M. Painter and C. W. Sabrosky); 3♂ 7♀ paratypes, Sabinal, N. Mex., July 17, 1932 (R. H., E. M. Painter and C. W. Sabrosky); 1♀ Carlsbad, N. Mex., July 17 (E. M. Painter); 2♂ Santa Rita Mts., August 18, 1935 (E. I. Beamer) (Jean Russell); 1♀ Wilcox, Ariz., August 10, 1930 (T. F. Winburn).

Variation. The striking "half and half" appearance of the abdomen of the female of this species distinguishes it from other known forms. The last three segments vary in color of pile from golden brown to almost black, the base of each hair is usually lighter in color than the tip, and the third segment usually bears lighter colored pile than the fourth and fifth. In the male the upper pleurae are largely black pilose in some specimens, white in others. In both sexes there is some variation in width of the third antennal segment. There is less variation in body size in this species than in many others. This species is most closely related to *apicula* Coq.

Lordotus bipartitus was collected in abundance in company with *Exoprosopa ingens* Cress. on blooms of *Mentzelia* sp. in some arroyos south of Steins. A male was found dead, fastened to hairs of the plant. One female was captured as the prey of a robber fly of the genus *Erax.*

Lordotus bucerus Coq.

Only the two female cotypes have been seen. In these most of the head, thorax and abdomen are clothed with appressed white, wooly tomentum overlaid by long, straight yellow pile except for the black pile on the upper side of the antennae and at the apex of the fourth abdominal segment. A drawing of the antenna is given on Plate 1. The palpi are rather long, with short, black pile on the distal part and longer yellow pile near the base. The wings are somewhat similar to *gibbus.* There is a contradiction in the original description in regard to the sex of the types. The male is unknown.

Lordotus diversus Coq.

The description of this species, which is in a periodical long out of print, is reproduced below.

"*Lordotus diversus* n. sp. Male, black, opaque. Second antennal joint twice as long as wide, but a trifle shorter than the first, the two together about equaling the third in length; base of the third joint yellowish; pile of upper side of first two joints short, sparse, mixed yellow and black, and the lower side yellow, long and dense. Pile of face yellow. Pile and sparse tomentum of occiput, thorax, scutellum and abdomen wholly dirty white, that on the pleura and venter purer white. Scutellum rounded behind. Apex of femora, whole of tibiae and base of tarsi yellow, their bristles black. Wings wholly hyaline, the costa beset with large, black teethlike projections. Stalk of halteres yellow-

ish, the knob white. *Female* differs from the male as follows: First two antennal joints yellow, their pile wholly golden yellow. Pile and tomentum of front, face, occiput, thorax, scutellum, abdomen, pleura and venter golden yellow. Femora wholly yellow, its pile and tomentum yellowish. Length, 6.5 to 10.5 mm.; the males on the average, the largest. San Diego. Four males and nine females in May."

"These two forms, although differing so much in coloration, are evidently the opposite sexes of the same species. I collected specimens of both forms at the same time and place, and did not take at the same time a single specimen of any other species of *Lordotus* having the same form of second antennal joint as both of these forms possess."

Coquillett was apparently correct in assuming that these two very different appearing forms belonged to the same species, since they have appeared together in several groups of specimens. The male is predominantly white pilose above, the female bright orange.

The species has an antennae of characteristic shape and proportion (Pl. 1), the third segment being broader than in related species and the two basal segments subequal. In the female the basal segments are bright orange in most specimens, though a few are brownish, the abdomen and thorax are densely covered with appressed tomentum and less dense pile, both golden. The tomentum in the center of the abdomen is sometimes denser and forms with the yellow posterior margins of the abdominal segments a ladderlike pattern. The male has the body pile both above and below white, but that of the face and antennae varies from dark brown to yellow. A very little appressed tomentum is present near the tip of the abdomen. In a male from Oregon the tomentum is more abundant and in this respect it is more like the type.

Specimens have been examined as follows:

ARIZONA: 1 ♂ Rincon Mts., Arizona, 2,300 ft., September 2, 1928 (A. A. Nichol); 1 ♂ 16 ♀ August 6, 1932 (Painter); 1 ♀ Nogales, September 20, 1931 (E. D. Ball); 1 ♂ Wilcox, August 11, 1930 (Winburn, Painter); 4 ♂ Mustang Mt., August 22, 1935; 1 ♀ Tucson, August 16, 1935 (E. I. Beamer); 2 ♀ Tucson, April 24, 1937 (W. Benedict); 1 ♀ San Bernardino Ranch, Cochise county, 3,750 ft., August (Snow).

CALIFORNIA: 3 ♀ Cal. (Baron); 1 ♀ Trinity county, altitude 5,500 ft., June 12, 1934; 1 ♂ 1 ♀ Azusa, May 24, 1925; 3 ♀ San Jacinto Mts., June 30, 1933 (R. H. Beamer).

OREGON: 3 ♀ 14 mi. east of Mitchell, 3,750 ft., August 13, 1929 (Scullen), taken on *Chrysothamnus* sp.; 1 ♂ Klamath Falls, June 24.

NEW MEXICO: 1 ♂ Sabinal, July 17, 1932 (Painter); 1 ♂ Stein, August 8, 1932.

TEXAS: Pecos, June 16 (E. M. and R. H. Painter); 1 ♂ Marathon, July 9, 1938 (Jean Russell); and 1 specimen 63 miles south of Alpine, Texas, July 11, 1938 (Jean Russell).

Lordotus divisus Cress. 1919 (Plate 1)

Lordotus niger Cress. 1923 New Synonym

Except for the white pile of the upper squamae the entire body is black pilose with chocolate brown reflection in certain lights. The wings are hyaline. This species appears on the wing earlier in the year than the others. The female is unknown.

In addition to the type the following specimens have been examined: 1 ♂ Huachuca Mts. Arizona; and 1 ♂ Newkirk, N. Mex. June 5, 1933 (J. D. Beamer); 1 ♂ San Carlos, Ariz., May (Duncan); 1 from Santa Rita Mts. Ariz., May.

Lordotus gibbus Loew

The type female in the Museum of Comparative Zoölogy, from Matamoras, Mexico, is in a fair state of preservation. The type has no black pile on the abdomen which is partially abraided. About the basal fourth of the femora is dark. The pile of the type is pale orange above, including that on the palpi.

This is the most common and widely distributed and also the most variable species in the genus. The distinguishing characters are the brownish spotted wings; the black base of the femora; the two pollinose stripes on the metanotum; the black antennae with the length of the second segment one and one-half to two times its width (Pl. 1). In other characters both males and females are variable. In size the specimens at hand range from 7 to 15 mm. The body pile varies in both sexes from bright orange to almost white, but in any collection of specimens the females as a group are always more darkly colored. In the female there are nearly always a few black hairs on the fourth and fifth abdominal segments, these often being more abundant among the more western specimens than among the eastern ones. The tomentose stripe down the center of the abdomen and the scattered tomentum of the thorax is always about the same color as pile. In the male the black pile present on the fifth segment usually extends completely across the dorsum and there is usually some black pile on the fourth and sixth segments. The costal teeth are sometimes lacking on the smaller and more northern specimens. The femora always have the extreme base black, but usually three-fourths the whole of each femur is black.

The 107 specimens which have been studied are from Kansas in September, Texas in June, September and October, Colorado in August and September, New Mexico in August and September, Wyoming in August, Utah in July, August and September, Nevada in August, Montana in August, Arizona in August and September, California in August, and Oregon in August.

Lordotus gibbus striatus n. subspecies.

Simiar to *Lordotus gibbus*, but differing in the presence of a stripe of silvery tomentum down the center of the dorsum.

Male. Ground color of body black, but grayish pollinose on the lower part of the thorax; posterior margins of ventral abdominal segments yellow; tibiae, base of tarsi, and apex of femora yellow to brownish. Head and antennae entirely yellow pilose, white tomentose on occiput, under parts of head, and front. Length of antennae, first segment, 0.46 mm.; second segment, 0.3 mm.; and third segment, 0.82 mm. Proboscis about twice as long as antennae. Thorax pale yellow pilose with two central gray pollinose stripes, sparsely slivery tomentose on posterior part of metanotum and scutellum. Abdomen pale yellow pilose, somewhat silvery at tip of abdomen, a band of black pile across center of segments four and five; venter somewhat darker yellow pilose, a stripe of silvery tomentum extends from segment one along the center of the abdomen as far as the apex of segment four. Legs whitish pilose and tomentose, spines black. Wings hyaline at the tip and posterior

border, the veins yellow to brown; the base of the wing and beyond the fork of the radial sector with veins darker than the intervening area, the wing membrane in this same area hyaline or in some lights, slightly milky; the brownish coloration in the wings extends slightly beyond the radius-median cross vein; costa denticulate. Haltere with yellow knob. Length of body, 14 mm.

Female. Similar to male, the basal antennal joints slightly brownish. The silvery tomentose stripe on the abdomen broader especially at the apices of the segments, a small patch of silvery tomentum at apex of segment five. Front of female yellow pilose and sparsely white tomentose. The base of the wing with somewhat more conspicuous whitish pile.

Holotype male, and *allotype* female, Jemez Springs N. Mex. August 27, in the collection of the author.

Paratypes. 3 ♂ 4 ♀ Jemez Springs, N. Mex., August 16, 18, 21, 27, and September 14; 1 ♀ Millcreek, near Blackfoot, Idaho, August 30, 1934 (Louise Ireland), in the James collection; 1 ♀ Portola, Cal., September 5, 1917, C. U. Expedit.; 2 ♀ "N. M." (In the Kansas University collection); 1 ♀ Humphrey's Peak, Ariz., 9,500 ft., August (Snow); and 2 ♂ Oak Creek Canyon, Ariz., 6,000 ft., August (F. H. Snow).

Seven females and eight males from Antioch, Cal., September 9, 1935, September 10, 1933 and September 10, 1936 (G. E.: R. M. Bohart), and Carson Pass, Cal., September 9, 1933, apparently belong to this subspecies. The tomentum of both males and females is much paler than that of the type series. The males lack the silvery tomentose stripe except in one case, and the females have a somewhat more conspicuous white tuft of pile at the tip of the abdomen. There appear to be no other differences. These fifteen specimens are not designated paratypes.

This species shows a similar range of size to that exhibited by *gibbus*. The type series varies from 15 to 7 mm. in length. The variation in the color of the pile is less than in *gibbus*.

Lordotus junceus Coq. (Pl. 1)

The description of this species, which is in a periodical long out of print, is reproduced below.

"*Lordotus junceus* n. sp.-Black, opaque. Front in the female densely gray pollinose, yellowish and white pilose, covered with minute black points; face in both sexes densely white pilose. First joint of antennae scarcely two-thirds as long as the third, second joint as wide as long; pile of upper side of first two joints brownish, that on the lower side more dense and white. Pile and tomentum of upper part of occiput in the male wholly yellowish-white, that on remaining part of occiput white. Thorax in the female grayish pollinose and covered with minute black points, in the male the pollen and points are almost wanting; pile and tomentum of thorax mixed white and yellowish-white, mostly of the latter color in the male. Scutellum rounded behind, its covering like that of the thorax. Pile and tomentum of pleura white, of the abdomen yellowish-white, that on the venter white; hind margins of abdominal segments 2 to 5, sometimes yellowish in the female. Pile and tomentum of legs white, bristles of tibiae and of tarsi black. Wings wholly hyaline, costa in the male destitute of teethlike projections. Stalks of halteres brown and yellow, the knob sulphur-yellow. Length, 5 to 9 mm. Los Angeles and San Diego county, California, 6 male and 3 female specimens, in May and June."

Only the type series and a single female from Rillito, Pima county, Arizona, June 2, 1935 (A. J. Basinger), have been seen. In the females the apical margins of abdominal segments 2, 3, and 4 are yellow in ground color. The tomentum of the female is much denser and more appressed than in most of the other species. This species is most closely related to *L. miscellus,* from which it differs in the absence of black or brown pile on the abdomen.

Lordotus miscellus Coq.

Coquillett's description omits several important details. The males have a broad band of black or brownish pile on the dorsum from near the center of the thorax to the tip of the abdomen. The appressed tomentose bands on the apices of the abdominal segments extend across the venter and up on the sides, but never across the dorsum. The dorsal part of the occiput and front of the metanotum are pale brownish pilose, sometimes almost white. The pile of the antennae (Pl. 1) is variable, black or brown above in both sexes, white to yellow below. Costa of male denticulate.

In the female the broad, dark pilose dorsal band tends to break up at each segment and between the thorax and scutellum. The pile is darker on the third and fourth segments. The narrow appressed tomentose bands run completely across the abdomen and there is a trace of a central longitudinal tomentose stripe in some specimens. The facial pile is more or less yellow and the tomentum white. The specimens vary in length from five to nine mm.

Specimens have been examined from California; 5 ♂ 6 ♀ Bridgeport, August 1933 (Winburn); and 11 specimens, Yuca Val. and Quail Spring, S. B. Co., Cal., October 5, 1934 (Basinger).

This species is nearest *junceus,* but in the female of the *miscellus* there is no tomentum in the center of the abdominal segments and in the male the tomentose bands are incomplete.

Lordotus planus O. S.

The female of this species was described by Coquillett. The type male is in excellent condition in the Museum of Comparative Zoölogy. The characteristic smoky pattern of the wing is variable; at most, eight pale spots are visible. Those which are usually most conspicuous lie on the fork of the radial sector, the radius-median cross vein and base of cell Cu_1; others may be present especially in the females, at apex of anal cell, base of cell M_2, base of 2d M_2, apex of cell R_2 and at tip of vein R_2. The veins near the base of the wing and in an area between the base of the discal cell and costal margin are paler in color than in the other parts of the wing. The costa of the *male* is not denticulate. In this sex the abdomen is uniformly white pilose and tomentose, the dorsum of thorax and upper part of occiput yellow pilose and white tomentose, the ventral parts with white vesture. The upper part of the face and antennae brown or black pilose, the lower parts and palpi white pilose. The ground color entirely brown or black in both sexes.

In the female the abdomen is white pilose with four more or less distinct yellow pilose spots on the center of each side of the first four segments, making eight patches in all. In some specimens these spots are pale or appear only on the second and third segments. The dorsum of the thorax is more or less yellow pilose. The upper part of occiput and front is yellow pilose and

white tomentose. The pile of antennae and upper part of face black or brown pilose. On the antennae the pile is frequently lighter in color below than above.

In spite of the pictured wings this species appears to be more closely related to *junceus* and *miscellus* than to *gibbus*.

Specimens have been seen as follows: 1 ♂ 1 ♀ Cobel Canyon, California, May 31, 1923; 1 ♂ S. E. San Bernardino county, California, June 8, 1930, 3,000 ft. (Hall and Hall); 1 ♂ 1 ♀ San Bernardino county, California, May; 3 ♀ San Jacinto Mountains, California, June 30, 1933 (R. H. Beamer).

Lordotus puella Will.

The type of this species has apparently been lost, but a male, Calexico, Cal., July 25, 1931 (Hahn W. Capps), in the University of Kansas collection agrees in all essentials with Williston's short description. The more important characters are as follows:

Male. Ground color black, only the tibiae somewhat reddish. Head and first segment of antennae white pilose, second segment black pilose. The pile of upper part of face somewhat yellowish. Pile of upper part of body and venter of abdomen yellowish, the remainder, especially on the sides of abdomen, white. Coxae and basal parts of femora white pilose, remainder of legs black pilose and tomentose. Wings hyaline, the costal, subcostal, and area about the fork of radial sector pale brownish to yellow. Costa not denticulate, but the small black spines are irregularly gathered in spots thus appearing as minute denticuli. Length of body, 15 mm.; antennae first segment, 0.44 mm.; second, 0.26 mm.; and third, 0.92 mm.

Lordolus pulchrissimus Will. (female) (1893)

Lordotus carus Cresson (male) (1923)

Lordotus pulcherrimus Aldrich (1905)

On account of the great difference in the appearance of the sexes it is not surprising that they have been described as separate species. The two have been associated in two different collections and in addition Williston had two males bearing the same data as the types and which he misidentified as *zona* Coq. The pile of the dorsum of the female varies in color from canary yellow to orange, the male is white pilose with a black pilose abdominal band. The size is variable, the females from Oregon measured, respectively, 5, 7, 8, 9.5, 11, 10, 10, 13 mm. in length and the males from 7 to 15 mm. In both sexes the pleurae are woolly pilose, the pteropleurae alone are bare; and the abdominal venter partly or wholly yellow in ground color. The drawing of the antenna (Pl. 1) is from the type of *Lordotus carus* Cress.

Male. The coxae and basal one-fourth to two-thirds of the femora are black in ground color; the trochanters, remainder of femora and tibiae yellow, the tarsi brown. The pile of the metanotum is about equal in length to the first antennal segment. In addition to the black hairs on the dorsum of the fourth abdominal segment there are a few on the fifth in some specimens, and usually a suggestion of yellow hairs on the ventral parts of these segments. Pile on the antennae pale yellow. The legs are white pilose and tomentose. The teeth on the costa of larger specimens are reduced in number in medium size specimens and lacking on the smallest.

Female. The hairs of the face and palpi are white, sometimes with the tips of the hairs yellow, the pleurae, coxae, femora, and anterior part of the venter of the abdomen white pilose. There are curly yellow scales beneath the pile on the front, occiput, notum, scutellum and a very few on the base and apex of abdominal segments and on a stripe down the middle. The head and thorax, except center of the notum, dull grayish, the dorsum of abdomen is polished black. The first two segments of antennae are yellowish, in ground color, sometimes the base of the third is also yellow; in some specimens the first segment is more or less dark and in several specimens the antennae entirely so. These antennal variations occur within a series taken at the same time and place.

Types *L. pulchrissimus* Will. in Snow collection, Kansas University; Reno, Nev., September 3, 1889, two cotype females and also two males bearing the same data, but misidentified as *zona*.

L. carus Cress. in collection of Academy of Natural Sciences of Philadelphia; type and paratype males, Hesperia, Mohave Desert, California, October 6, 1923 (F. M. Jones).

Additional specimens studied: 8♂ 8♀ Antelope Mt., Harney, county, Oregon, 6,500 ft., August 4 to 19 (Frewing); 5♂ 14♀ Bridgeport, Cal., August, 1933, (Winburn); 1♂ Carson Pass, Cal., September 3, 1933; 1♀ Bishop, Inya county, California, elev. 8,400 ft., August 2, 1936; 4♀ Tucson, Ariz., July 2, 1923, October 2, 1923, October 4, 1923; Pima county, Arizona, September 27, 1925 (Dean Thayer); 2♀ Tucson, Ariz., July 1, 1921, October 2, 1923; 1♂ headwaters of the little Owyhee river, Nevada, August 24, 1934 (Stafford); 2♂ Reno, Nev., August 31, 1889; 1♂ Manzanola, Colo., September 1, 1932 (James); 1♂ Scott county, Kansas, September 24, 1934 (Wilbur); 4♀ Masonville, Colo., September 18, 1937 (James); 1♀ Stanton county, Kansas September 22, 1934 (Wilbur); 1♀ 2♂ Scott county, Kansas, September 24, 1934 (Wilbur), appear to belong to this species, but they have much paler yellow pile and entirely black antennae. Both these characters occur to some extent in the longer series mentioned above.

Lordotus sororculus Will.

One male cotype from Coso Valley is in the National Museum, but the other specimen mentioned by Williston from Kern county, California, is missing. There are, however, several males and females from that county which belonged to the Coquillett collection. If the two sexes are correctly associated, as seems probable, the species may be briefly characterized as follows:

Male. Ground color entirely black. Head and antennae (Pl. 1) black pilose, upper part of occiput white or pale yellowish pilose. Thorax white pilose above, scutellum yellowish pilose, ventral parts of thorax and legs black pilose. Abdomen white pilose above and below with a few dark hairs on the first abdominal segment below. Between the areas of black and white pile some individual hairs are yellowish. The male has no tomentum and the costa of wing is not denticulate.

Female. Ground color black, tibiae and posterior margins of abdominal sternites yellow. Head white tomentose and pale yellow pilose on front and occiput; antennae and lower part of head black pilose, face shining brownish

to black pilose, the tips of many hairs whitish. Thorax white tomentose above, the pile of the dorsal half white, but with pale yellowish hairs intermixed, especially on the posterior part of metanotum and scutellum. Lower parts of thorax more or less bare, a few dark-brown hairs, coxae and femora black pilose, femora and tibiae with yellowish scales. Abdomen white tomentose and pilose with brown pile on the first sternite in some specimens, on others the tomentum forms a typical pattern, being denser on the incisures and fifth segment and in a central longitudinal stripe. Wings hyaline in both sexes.

This species is close to *apicula* but distinguishable by means of the characters given in the key.

Specimens in addition to those mentioned above have been seen from 1 ♂ Kern county, California (Coll. Coquillett); 1 ♀ Kern county, California; 1 ♂ Barboquivari Mountains, Arizona, July 19, 1937 (W. Benedict).

Lordotus zona Coq.

Two cotypes are in the National Museum. The principle characteristics are as follows:

Male. Ground color black, one-half or more of the abdominal sternites yellow, legs including apices of coxae but not the bases, yellow. Head white pilose and tomentose, antennae (Pl. 1) pale yellow pilose. Thorax, abdomen, and legs white pilose, the body pile somewhat yellowish above. A conspicuous band of black pile across the dorsum of the fourth segment. Wings hyaline, the costal, subcostal, cell M and basal two-thirds of cell R_1 yellowish. Costa denticulate. Length of body, 10 to 12 mm.

Contrary to the description the two remaining cotypes have no black pile on the fifth abdominal segment, but specimens in the National Museum from Los Angeles county, California, and a male in the author's collection from Mt. Wilson, Cal., August 4, 1915, have more or less black pile on segments five and six. There are no other visible differences. A male from Tucson, Ariz., July 24, 1921, has the body pile similar to the type but the extreme bases of the front femora and the coxae are brown. These differences are believed to be interspecific, but the material is insufficient to be certain.

A female associated with the male from Mt. Wilson and probably belonging to this species has the following characteristics: Ground color black, most of abdominal venter, legs including coxae and first two segments of antennae (third missing) yellow. Head and under parts of thorax gray pollinose. Pile and tomentum of head, antennae, thorax, legs and abdomen golden yellow, but tending to be white on lower part of head, face, pleurae, and coxae. On the abdomen the tomentum is sparse but somewhat more abundant in the center and along the segmental margins. Wings hyaline, colored areas paler than in male.

This species appears most closely related to *pulchrissimus.*

Genus GEMINARIA Coq.

This genus is identical with *Lordotus* in most characters, including the peculiar structure of the female abdomen, with only five segments normally visible. The specimens seen differ only in the longitudinal groove in the scutellum and perhaps in having the palpi of approximately the same length as the antennae. The grooved scutellum occurs in several other genera, notably *Epacmus,* where there is some evidence that it may not even be of specific

value. The validity of this single character for the separation of genera is perhaps open to question until longer series are available for study. The genotype can be separated from the only other described species, *G. pellucida* by the following key.

PAGE

1. Wings with brown spots on the r-m cross vein, at base of Cu_1, and a faint spot near tip of cell R_1..*pellucida* 293

   Wings with numerous brown spots at least eight in number situated along veins *canalis* 293

Geminaria canalis (Coq.)

The single type female in the National Museum is in very poor condition. It is from Los Angeles, Cal. The following specimens are also in the same museum: 1 ♂ Sacramento county, California (Coquillett); 2 ♂ Monrovia Canyon, California, July 4, 1931 (D. Martin); and June 28 (C. H. Martin). In my collection there is a female, Monrovia Canyon, California, August 3, 1930 (Painter) and another female Cajon, Cal., July 24, 1930 (Painter). The author is indebted to Doctor and Mrs. Martin for taking him to the habitat of this and other interesting species of Bombyliidae in Monrovia.

Geminaria pellucida Coq.

This species appears to be known only from the single type male in the National Museum. It bears the label, Los Angeles, Cal. The faint spot near the tip of cell R_1, is not mentioned by Coquillett.

Genus CONOPHORUS Meig.

The key which Coquillett gives (1894, p. 101) appears to be correct for the species covered. The characters used appear trivial but scarcity of material prevents any judgment as to their validity. This genus includes species with both "two and three submarginal cells" as has been demonstrated for the Palaearctic species by Paramonov (1929) and Engel. Those species with two cells have been classified as *Codionus* Rondani, 1873, and *Calopelta* Greene, 1921. The type specimens of all species except *melanocerata* Bigot and *pictipennis* Macq. have been examined.

Conophorus limbata (Lw.)

The type which appears to be a female is headless and lacks one wing. A figure of the other, showing the typical wing pattern is given (Pl. 1). All the vesture remaining on the badly rubbed abdomen is white or yellowish except for a very few long black hairs on segments four and five of the abdomen. No additional specimens have been seen.

Conophorus fallax (Greene) (new combination)

(*Calopelta fallax*) Greene (1921)

This species, described as the genotype of *Calopelta,* usually has only two submarginal cells. It may be separated from *atradula* (Lw.) only by the presence of more light colored pile on the body and legs and in the more hyaline wings. A specimen of *atradula* from Utah has two submarginal cells in one wing and three in the other. The validity of the distinction between these two species is perhaps open to question. Specimens identified as *fallax* have been seen from British Columbia, Washington, Utah, and Arizona.

Conophorus cristatus n. sp.

Male. Ground color grayish black, entirely opaque, the abdomen somewhat brownish. Head white pilose, ocellar triangle black pilose, a few long, black hairs on the face. First and second antennal segments sparsely black pilose with a few pale yellowish white hairs intermixed especially on the lower side. Thorax white pilose and tomentose with a few black hairs intermixed on the mesonotum, scutellum and in front of the wings. Wings translucent, tinged with black which is darker along all the veins and almost opaque along the front part of the wing especially in the subcosta, costa, and base of R_1. Sectorial cross vein present. Costa of the male with small teethlike projection. Hairs of alulae white. Knob of halteres yellow, the stalk brownish. Legs yellowish pilose, the hairs of the femora long and black. Tibial spines black. Coxae white pilose, the larger hairs with a yellowish tinge. Dorsum of the abdomen curly white pilose with twelve or fifteen long, black hairs along the posterior margin of each segment. The sides of the abdomen white pilose, the anterior parts of the second and following segments with black pile of the same length, a few longer black hairs on the sides of the segments, especially towards the posterior parts. Venter entirely yellowish pilose. Length of body, 11 mm.; of wing, 9 mm.

Female. Almost identical with male, a few black hairs on the occiput, front sparsely long black, and short white pilose. No projections on the costa.

Holotype. Male, Claremont, Cal., November 17, 1938 (Ralph Priddy).

Allotype. Female, Claremont, Cal., November 30, 1938 (Ralph Priddy).

Paratypes. Three males, Claremont, Cal., November 17, 1938, and 1 male, November 30, 1938 (Ralph Priddy).

This species would be classified in Coquillett's key under couplet four, but differs from the three species there recorded. It differs from *melanocerata* in the presence of teethlike projections on the male costa, from *serrata* in the the color of the pile on the thorax and scutellum, from *limbata* in the color of the pile of the antennae and head, and from all three in the presence of the tufts of black hairs on the anterior margins of the segments. It is more closely related to *nigripennis,* but differs from that species in having much more abundant lighter colored abdominal pile and in lacking the shining areas on the abdominal segments.

Genus ALDRICHIA Coq.

Aldrichia auripuncta n. sp.

This species differs from *A. ehrmanii* in its darker wings, black pilose occiput, golden tomentose thorax, and in the proportions of the antenna (Pl. 2).

Female. Black, pleurae lightly grayish pollinose; pile of head and four front coxae black, a few white curly scales on front above antennae. Thorax with a few stiff black hairs, a patch of curly white ones on the mesopleurae, the dorsum of the thorax conspicuously golden tomentose. Abdomen similar to *ehrmanii,* sparsely white pilose and tomentose, a few black hairs on the posterior margins of the segments and at the tip of the abdomen. Wings blackish brown, the center of the most of the cells lighter, squamae white, with white hairs. Length, 10 mm.

Holotype. Female, Wooster, Ohio, June 24, 1907. (In Illinois University collection.)

Paratype. Female, Fairfield county, Ohio, Jacobs Ladder, June 16, 1931 (Edward S. Thomas), coll. (In Ohio State University collection.)

In *A. ehrmanii* the segments of the antennae are subequal; in *auripuncta* the second segment is distinctly longer than either of the others.

Aldrichia ehrmanii Coq.

The single type in the U. S. National Museum is a female. The male is similar in general appearance but is less densely pilose and may be briefly described as follows:

Ground color black to dark brown. Pile sparse, long and black on head, thorax, dorsum of abdomen, and hind coxae; white on hind coxae, alulae, sides and venter of first abdominal segments. The last abdominal segments and genitalia largely black pilose. The dorsum of the abdomen is very sparsely covered with curly tomentum. Wings smoky as in the female. Redescribed from a male, Douglas county, Kansas, May 19, 1923 (W. J. Brown), and two males, Columbus, Ohio, May 26, 1901, and June 6, 1924. Specimens of this rare, but widely distributed species have been identified also from the following localities: 4 specimens from Atherton, Mo., May 16 and 21, 1902; 1, Atherton, Mo., June 10, 1917; 1 from Ithaca, N. Y., June 10, 1916; 3 from Ithaca, N. Y., June 5, 20, 1934 and 1935 (Franclemont); 1 from Loudonville, Ohio, June 6, 1925 (J. S. Hine); 1 from Ira, Summit county, Ohio, July 1, 1920 (J. S. Hine); 1 from Dory Lake, Michigan, June 20, 1928; 1 from Oregon, Ill., June 20, 1920 on *Amorpha;* 1 from White Heath, Ill., May 28, 1916, on *Thaspium barbinode;* 1 from Dubois, Ill., May 10, 1918 (J. R. M.); two same locality, May 22, 23, 1917; and 4. same locality, May 14, 1916, on flowers of dewberry.

Genus PANTARBES Osten Sacken

Three species are known, *P. willistoni* O. S. being rare in collections thus far. They may be separated as follows:

PAGE

1. Pile and tomentum mostly brown or black........................... *willistoni* 296
   Pile and tomentum mostly white or yellowish........................... 2
2. Wings more or less infuscated, expecially on r-m cross vein and base of cell Cu_1; basal antennal segments yellowish; appressed pile if present on dorsum confined to margins of abdominal segments; erect hair of abdomen all of about the same length; proboscis rarely surpassing the antennae when projecting forward; tibiae yellowish .... *capito* 296
   Wings hyaline; basal antennal segments black; appressed pile present on dorsum of abdomen and thorax; the longer hairs frequently present on posterior margins of segments are often yellow or brown; proboscis extending much beyond antennae; tibiae brown .... *pusio* 296

The characters given for separating the last two species are derived from series of specimens from single localities. In these series there has been some variation in respect to each of the characters. This is especially true of the length of the hairs on the abdomen. Specimens from the great basin states show more variation from the typical ones than do specimens from California and Arizona, although typical specimens of *pusio* have been seen from Utah.

Specimens have lately been studied from the following localities:

Pantarbes capito O. S.

CALIFORNIA: 12 ♂ 9 ♀ Mohave, Cal., April 10, 1936 (G. E.: R. M. Bohart); 1 ♂ Mt. Diablo, Cal., April 22, 1933; 1 ♀ La Panza, Cal., April 27, 1935; Sacramento, Cal., No. 358 (C. C. Wilson).

WYOMING: 1 ♂ near Lander, Wyo., 5,000 to 8,000 ft., July. (Roy Moodie).

Pantarbes pusio O. S.

ARIZONA: 1 ♀ Rincon Mts., Ariz., altitude 4,000 ft., April 9, 1925 (A. A. Nichol); 1 ♂ 1 ♀ Baboquivari Mts., Ariz., April (D. K. Duncan); 1 ♀ Tempe, Ariz., April (D. K. Duncan).

CALIFORNIA: 1 Mt. Diablo, Cal., April 22, 1933; 1 Mt. Hamilton, Cal., June 2, 1933; 1 Tioga Pass, Cal., July 3, 1933; 1 La Panza, Cal., April 27, 1935 (C. C. Wilson) Sacramento, No. 358.

UTAH: 1 ♂ Cove, June 11, 1938 (Knowlton, Nye) 1 ♂ Callao, April 28.

WYOMING: 3 ♂ 24 ♀ near Lander, Wyo., 5,000 to 8,000 ft., June, July (Roy Moodie).

Pantarbes willistoni O. S.

CALIFORNIA: 1 ♀ Mohave, April 10, 1936 (G. E.: P. M. Bohart).

TEXAS: 1 ♀ El Paso, April 5, 1902.

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———
A review of the Bombyliid genus *Heterostylum*.
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———
New subgenera and species of Bombyliidae.
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Two new North American Diptera.
Insecutor Inscitiae Menstruus 4:69-72. 1916.

PLATE I

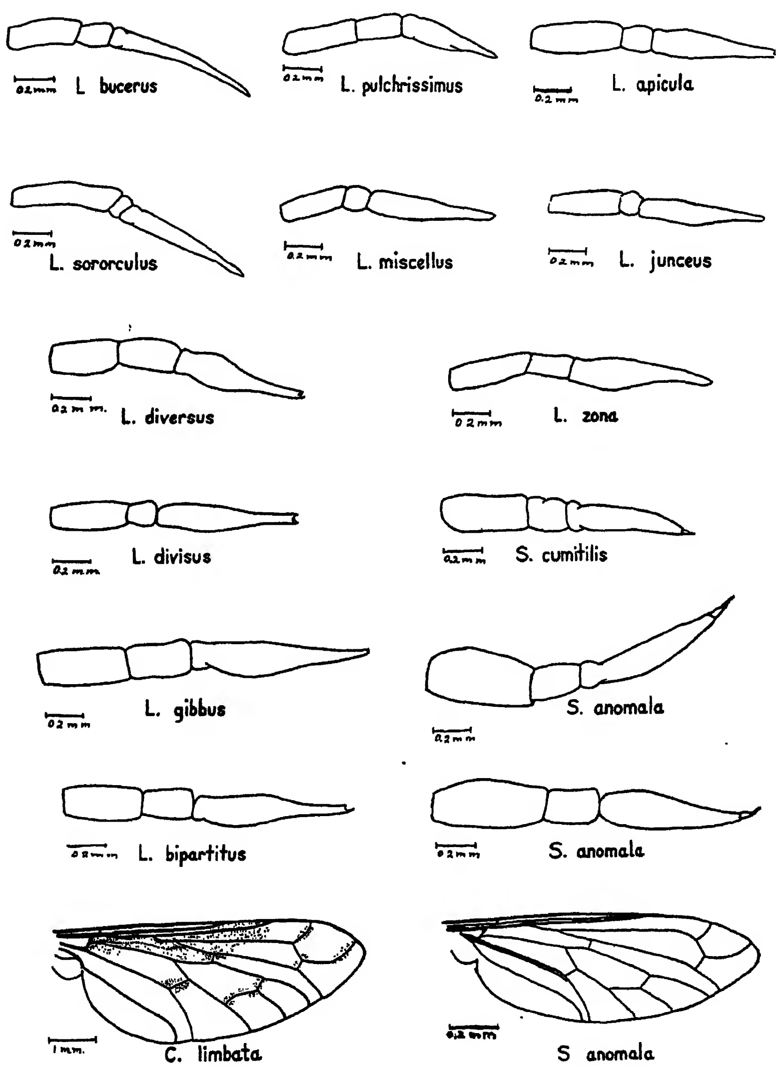
DRAWINGS OF ANTENNAE

Lordotus apicula Coq. Female. Side view. In the author's collection.
Lordotus bipartitus Painter. Holotype male. Side view. In the author's collection.
Lordotus bucerus Coq. Type female No. 12235, in U. S. National Museum. Side view.
Lordotus diversus Coq. Female. Side view. In the author's collection.
Lordotus divisus Cress. Homotype male. Side view. In the author's collection.
Lordotus gibbus Coq. Female. Side view. In author's collection.
Lordotus junceus Coq. Male cotype. Side view. U. S. National Museum.
Lordotus miscellus Coq. Male. Side view. In the author's collection.
Lordotus pulchrissimus Will. (*carus* Cress.) Side view. Drawn from the male type *carus* Cress. in the Academy of Natural Sciences.
Lordotus sororculus Will. Type male. Side view. In the U. S. National Museum.
Lordotus zona Coq. Male. Side view. In the author's collection.
Sparnopolius anomala Painter. Holotype male. Top and side view. In the author's collection.
Sparnopolius cumatilis Grote. Lectotype 66. Side view. Academy of Natural Sciences.

WING DRAWINGS

Conophorus limbata (Lw.) Type female. No. 17200 in the Museum of Comparative Zoölogy.
Sparnopolius anomala Painter. Holotype male. In the author's collection.

Plate I


0.2 mm
L. bucerus
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L. pulchrissimus
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L. apicula
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L. sororculus
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L. miscellus
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L. junceus
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L. diversus
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L. zona
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L. divisus
0.2 mm
S. cumitilis
0.2 mm
L. gibbus
0.2 mm
S. anomala
0.2 mm
L. bipartitus
0.2 mm
S. anomala
1 mm.
C. limbata
0.2 mm
S anomala

PLATE II

DRAWINGS OF ANTENNAE

Aldrichia auripuncta Painter. Holotype female. Side view. In University of Illinois collection.

Aldrichia ehrmanii Coq. Side view. A typical specimen in the author's collection.

Heterostylum englehardti Painter. Type female. Side view. In the author's collection.

Heterostylum novum (Will.). Cotype male, from cotype of *B. recurvus* Coq. in the U. S. National Museum.

Heterostylum robustum (O. S.). Male. Side view. A typical male in the author's collection.

Heterostylum vierecki Cress. Male paratype. Side view. In the Academy of Natural Sciences.

Parabombylius maculosus Painter. Male and female. Side view. In the author's collection.

Parabombylius pulcher Painter. Type female. Side view. In the author's collection.

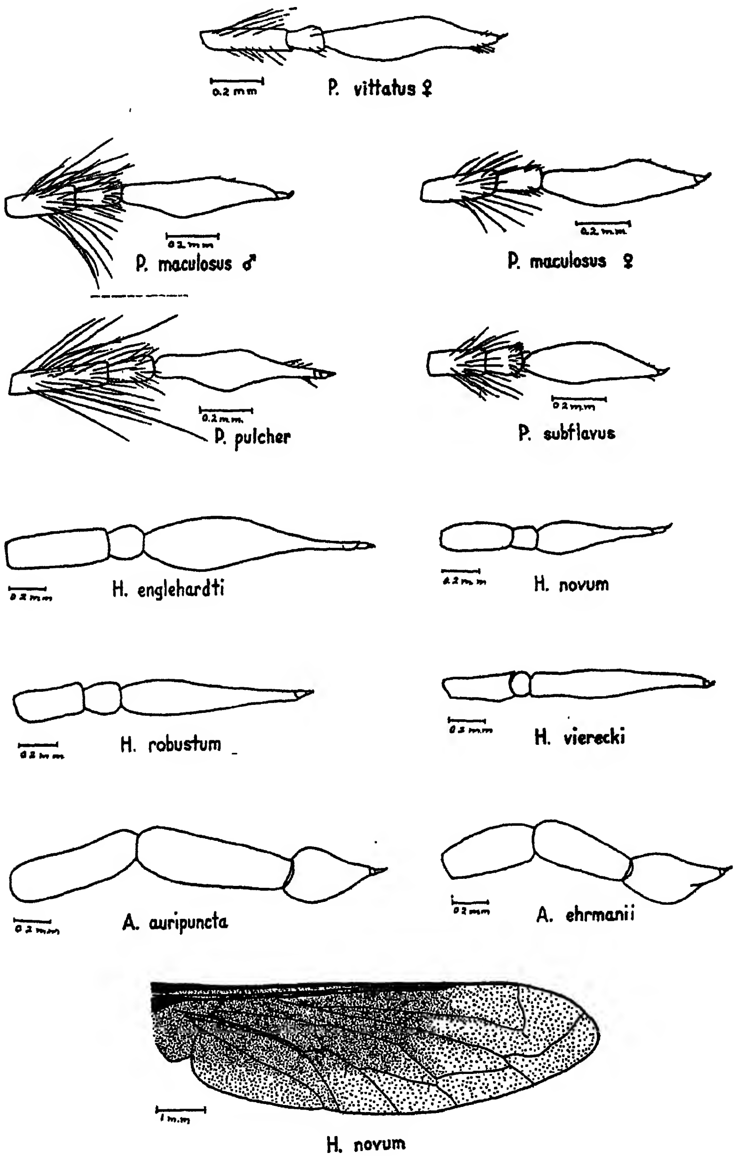
Parabombylius subflavus Painter. Type male. Side view. In the U. S. National Museum.

Parabombylius vittatus Painter. Type female. Side view. In the U. S. National Museum.

WING DRAWING

Heterostylum novum (Will.) from cotype of *B. recurvus* Coq. In the U. S. National Museum.

PLATE II


P. vittatus ♀
P. maculosus ♂
P. maculosus ♀
P. pulcher
P. subflavus
H. englehardti
H. novum
H. robustum
H. vierecki
A. auripuncta
A. ehrmanii
H. novum

The Eighth Annual Insect Population Summary of Kansas, Covering the Year 1938 [1]

ROGER C. SMITH and E. G. KELLY, Kansas Agricultural Experiment Station, Manhattan, Kan.

The eighth annual insect population summary for Kansas involves only one change in method from the previous one (Smith and Kelly, 1937), in that the illustrations of the insects upon which data were requested were not sent with the questionnaires. A brief review of aims and methods in making and recording insect population summaries is added to this report.

REVIEW OF LITERATURE ON INSECT POPULATION SUMMARIES

The senior author gathered information from representatives of the various states concerning records and published summaries of the population of one or more insects in the states and published the findings (Smith, 1938 a). In general it was found that practically all states made reports to the Insect Pest Survey of the U. S. Bureau of Entomology and Plant Quarantine and that these mimeographed reports largely served as their record. A few states such as Connecticut, Ohio, Illinois, Indiana, Montana, and Utah publish population notes in annual reports of the state entomologists. The Kansas survey which was briefly described in the paper is similar to the Indiana survey.

A search through the literature revealed the paper by Hyslop (1927) in which a method of scoring populations in a manner similar to the one used in each of the eight Kansas summaries was suggested. Hyslop deplored the lack of uniformity in concepts of abundance or of injuries and that data on this subject generally were not comparable. He suggested selecting 10 or 20 species of pests and that the appropriate descriptive term for each would be determined as follows: 0—The insect in question is absent; 1-20% of area or of plants, infested or damaged—the species is present in neglible abundance; 21-40%—the species is moderately abundant; 41-60%—the species is abundant; 61-80%—very abundant; 81-100%—epidemic.

These categories are essentially those decided upon independently by the writers for the Kansas surveys. Hyslop pointed out further that these degrees are not easily determined for each species, since each must be considered by itself, but if this is done results will be comparable. This method, however, could not be used for a nation-wide survey, but the writers contend that such a scheme is readily adaptable to an area the size of a state, where those in charge of the survey follow the daily progress of the insects and can interpret reports in the light of their own observations.

For certain kinds of insects, such as the Hessian fly (Larrimer, 1934), definite determinations of population numbers can be made by counting infested stalks or culms. DeLong (1932) showed that in a survey of leaf hoppers, results of

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Contribution No. 471 from the Department of Entomology. This eighth annual summary is based on work on Agricultural Experiment Station Project No. 6. Information was supplied by all departmental colleagues and by members of the local Laboratory of the Bureau of Entomology and Plant Quarantine. Misses Frieda Landis and Frances Cole, N. Y. A. students, and Dale E. Johnson assisted with the summarizing of data and in making the plate.

collecting by sweeps or by killing them quickly vary with temperature, humidity, wind velocity, position of sun, variations in the use of insect nets, host plants, farm practices, migratory habits, and with other variables. Obviously, as Lockwood (1931) stated, it is impossible to count an entire population unit. We must use all methods of observation and discovery of forms as indicators. Any descriptive terms of population such as those used in annual reports must be consciously or unconsciously translated into mathematical concepts in thought.

Reasons and methods for making such annual surveys have been given by Hyslop (1931) and Leonard (1932). The latter classified his insect notes under crop headings, while the Kansas survey uses insect headings.

SOURCES OF INFORMATION FOR THIS SUMMARY

The usual field observations were made by staff members in the course of investigational work and travels over the state. In addition, questionnaires returned by correspondents were summarized as follows:

TABLE I.—Questionnaires returned and summarized for this report

Group No.	Composition of the Group.	Date.	Number of reports.	Date.	Number of reports.
I	Entomologists in the state................	July	19	Oct.	23
II	County agricultural agents...............	July	83	Oct.	79
III	Farmers, mostly college graduates.........	July	14	Oct.	17
IV	Vocational agricultural teachers, selected...	July	27	Oct.	38
	Total reports....................	....	143	....	157

Grand total of all questionnaires summarized................. 300

TABLE II.—Summary of weather data for the state of Kansas for the period September 1, 1937, to December 31, 1938

Month.	Temperatures, degrees Fahrenheit.					Precipitation, in inches.					
	State average	Maximum.	Minimum.	Average for fifty years.	Departure from normal.	State average.	Average for fifty years.	Departure from normal.	Eastern third.	Middle third.	Western third.
September, 1937	71.3	106	30	69.6	+1.7	1.90	2.83	—0.93	2.38	2.05	1.27
October	57.2	96	18	57.0	+0.2	1.43	1.95	—0.52	1.49	1.59	1.22
November	41.0	87	—2	43.2	+2.2	0.67	1.27	—0.60	1.26	0.60	0.15
December	31.8	73	—8	32.8	—1.0	0.53	0.85	—0.32	0.92	0.38	0.29
January, 1938	34.6	75	—12	29.7	+4.9	0.45	0.67	—0.22	1.17	0.10	0.09
February	37.7	80	—5	33.0	+4.7	1.16	1.00	+0.16	1.48	1.50	0.51
March	51.0	89	12	43.6	+7.4	2.06	1.43	+0.63	3.16	1.71	1.28
April	55.0	92	13	54.7	+0.1	2.41	2.53	—0.12	2.32	2.56	2.36
May	63.5	99	26	63.8	—0.3	7.56	3.86	+3.70	9.75	8.26	4.66
June	73.8	104	42	73.8	0.0	4.08	3.98	+0.10	5.43	4.39	2.41
July	80.9	110	50	79.1	+1.8	2.90	3.19	—0.29	3.58	2.71	2.42
August	82.9	111	48	77.8	+5.1	2.53	3.10	—0.57	3.34	3.19	1.05
September	72.3	103	31	69.7	+2.6	2.19	2.82	—0.63	2.24	1.88	2.45
October	64.8	100	11	57.1	+7.7	0.33	1.02	—1.58	0.49	0.15	0.35
November	42.6	83	—2	43.2	—0.6	1.40	1.28	+0.12	2.45	1.57	0.17
December	36.2	78	—10	33.0	+3.2	0.20	0.84	—0.64	0.31	0.11	0.17
Averages or totals for 1938		111	—12	54.9	+3.0	27.27	26.56	+0.71	35.75	28.13	17.92

SUMMARY OF WEATHER CONDITIONS IN KANSAS DURING 1938[2]

January opened with mild, dry, comparatively pleasant weather, but unfavorable for wheat and other vegetation. Dust storms were frequent. Moisture was markedly deficient. Cold waves occurred on the 24th, 25th, 30th and 31st.

February was milder than usual and had the first above-normal precipitation in more than a year. The rains occurred mostly in the eastern two-thirds of the state. The temperature during the early part of the month was abnormally high, and was followed by a cold period during the latter part.

March was the wettest for seven years, and the third mildest on record. In general, good growing weather for wheat, oats and pastures occurred.

April was characterized by heavy snows early in the month, followed by ample showers which put the top soil in good condition for plant growth. Mild temperatures and sufficient sunshine the latter part of the month made fine growing weather. Wheat made rapid growth, being about 10 days ahead of normal.

May had more rain than any except three Mays in 51 years. Rains fell with unusual frequency all over the state. The soil became too wet for wheat in the eastern and south central portions.

June had abundant rains over most of the eastern half of the state and in many western counties, with temperatures and sunshine ranging near normal. There was an unusual number of hail and wind storms, and overflows of streams caused damage.

July was the coolest the state experienced in seven years, and the second wettest in six years. There was less damage from hail, wind storms, and overflows than in June. The month was favorable for corn, pastures and alfalfa, but less favorable than usual for combining and threshing grain.

August was the fifth hottest snce 1887. There were some rains in the eastern half of the state, but the western half was dry. Corn deteriorated during the first of the month, but its condition improved in the eastern part of the state near the close of the month.

September had some of the heaviest rains on record in southwestern Kansas, but was one of the driest on record in many northeastern and north central counties. Temperatures were above normal.

October was the warmest and second driest on record in 52 years. Taken with September, this was the driest two-month record in the state except one. It was a sunshiny month but unfavorable for growth of wheat in the eastern half.

November was a normal fall month, but with insufficient moisture in the central and western portions, and temperatures were above normal. It was a pleasant month, but largely unfavorable for wheat.

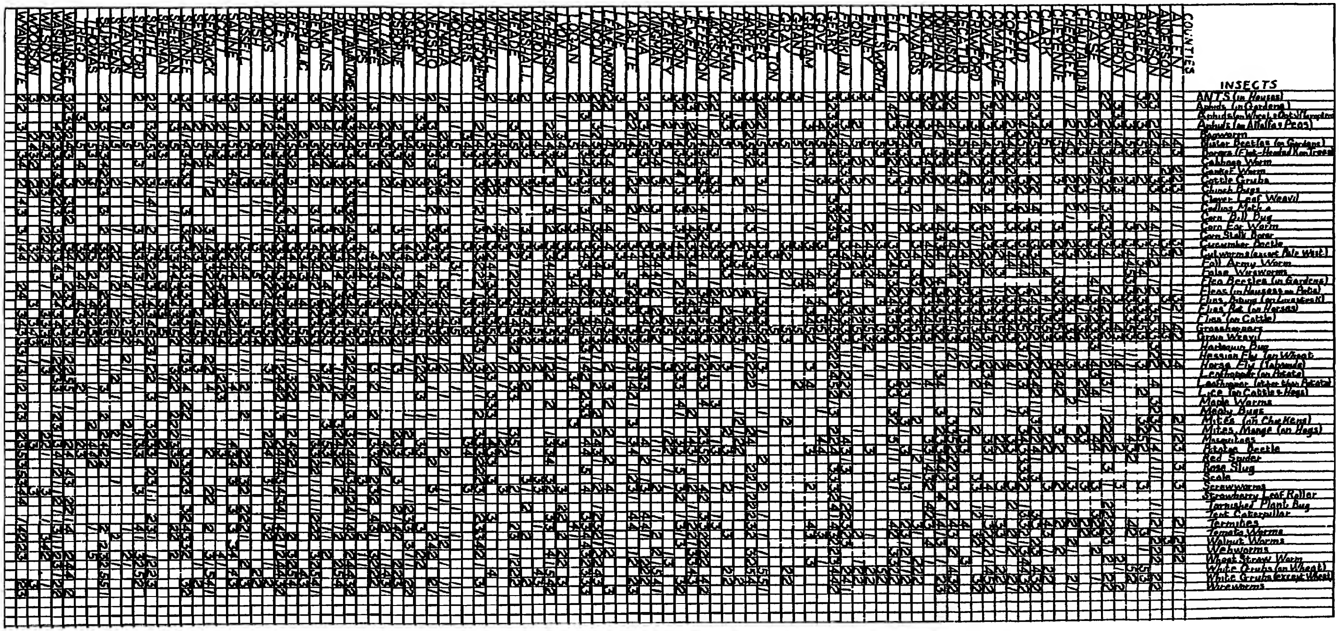
December was one of the mildest, driest and most sunshiny on record. The fall of moisture was deficient in nearly every county, and inadequate for current needs except in the southwestern and south central counties.

2. Largely summarized from Flora, S. D., Climatological Data, Kansas section, U. S. Dept. Agr. Weather Bureau 52. 1938.

EXPLANATION OF PLATE

Population summary from the questionnaires returned in July and October from all the counties except Butler, Greeley, Greenwood, Wallace and Wichita counties.

KEY: 0, the species is practically absent; 1, scarce; 2 common but not injurious; 3, plentiful and some damage was done; 4, abundant, serious injury to some fields in many communities; 5, outbreak or as plentiful as a common species has been in years of largest populations.



In general crops were severely attacked by insects. Severe drouth conditions from July on made growing conditions so difficult for crops that recovery from a normal population of insects was slow or impossible. Weather conditions brought about a gradual reduction in grasshoppers, chinch bugs, and hessian fly, but favored cutworms and false wire worms.

GENERAL OBSERVATIONS ON THE MORE NOTEWORTHY INSECT FEATURES OF THE YEAR

Ants were fully as troublesome and abundant in 1938 as in 1937, and some species were more so. The yellow ant emerged in about the same numbers as in previous years. Pharaoh's ant brought more complaints than usual. The chief increase in correspondence regarding this pest concerned the large group of carpenter ants, especially several species of *Crematogaster*. Many specimens were sent by collectors who thought they were termites. This species of ant was troublesome in homes and outbuildings continuously from about March to the middle of November. Correspondence appeared to come principally from the central third of the state.

Aphids

Aphids in general were less plentiful and less destructive in the state than in 1937. A severe widespread outbreak of the apple-grain aphid (*Rhopalosiphum prunifoliae*) on fall-sown wheat was a feature of 1938. The aphids apparently flew into the state and the species was widely mistaken for green bug. They were first observed about the middle of September, but they reached a peak the last of October and early November and continued plentiful up to the middle of December. The outbreak and damage occurred from Saline and Barton counties west. They were collected in Gray, Lane, Thomas, Barton, Ness and Riley counties. The aphids clustered around the base of the plants and on the roots. By early November, in many fields the wheat plants were too large to be injured by them.

Green bug (*Toxoptera graminum*) first developed as an outbreak in North Texas (Plainview) in knee-high wheat, which was reported to have been frost injured, and spread northward. They were first reported in Kansas on April 15th on wheat spotted over five fields in the southeast corner of Clark and southwest corner of Comanche counties. The infestation was light and no injury was done because the wheat grew so rapidly. A little damage was done to wheat and oats in early May in Marion and Harvey counties. A survey showed, however, in general only a scattered infestation in most wheat, oats and barley fields. It was expected that they would develop on frost injured oats, but they failed to do so.

Pea aphids were found in small numbers in many alfalfa fields from the middle of March on. Alfalfa grew rapidly because of the moist surface soil from timely rains early in March. By the middle of April, pea aphids could be readily found in all alfalfa fields. Alfalfa was somewhat injured by the blizzard in the state on April 8. The first report of injury to alfalfa by pea aphids came from Canadian, Tex., on April 11. The first outbreak in Kansas was discovered on April 13, in Barber county, 12 miles east of Medicine Lodge. The aphids were confined to a spot 20 by 80 feet in area. They were plentiful about the middle of April at Oxford (Cowley county), and at Argonia (Sum-

ner county), but no real injury was done. The frost injury all over the state, however, gave alfalfa clumps the appearance of severe aphid injury. Subsequent growing conditions were excellent and the slight aphid injury was soon overcome. The aphids remained scattered and below damaging numbers throughout April, but reached threatening numbers by May 10th. Alfalfa was then ready to be cut, so no injury was done to the crop. The aphids were practically gone by May 20th. Rains, followed by cool, humid weather, favored the development of a fungous disease which destroyed many, and the usual predators were plentiful. By the latter part of May the aphids were plentiful only on peas. This aphid increased in numbers slightly about the middle of June, but the numbers declined to complete absence during the hot month of July. Pea aphids were almost wholly absent during the fall in Kansas. It was not until early October that some specimens were found in Douglas county and brought to Manhattan for winter studies on this insect.

Melon aphids developed to heavy population on cucumbers during early July and on cantaloupes during the latter part of July and all of August. These aphids cut short the cantaloupe crop in the Kansas river valley as far west as Abilene. Fully a third of the vines died in Riley county in spite of correct dusting practices, and another third appeared irreparably injured. During August most of the cucumbers and pumpkins died as a result of damage by aphids, other pests and drouth.

The corn leaf aphid (*Aphis maidis* Fitch) was scarce all year in the state. Its population was much below normal.

Several species of black aphids were observed in numbers during the year. *Aphis rumex* was plentiful in Riley county on ragweeds throughout June. Winged specimens of the large black sycamore aphid were sent in from oak at Skinner's nursery, Topeka. They were, probably incorrectly, blamed for the poor condition of the oak trees.

The *redbud aphid* was more plentiful locally than for two or three years on 3-year-old redbud trees. At one residence large numbers of overwintering eggs were found during November.

Corn root aphids were not a pest in 1938 nor have they been numerous during the drouth years.

Bag worms had a normal population on some evergreens in Southeastern Kansas in 1938, but were practically absent in Riley county. This species hatched May 14-20 in Southeastern Kansas, but, while plentiful, did no damage.

The *beet web worm* (*Loxostege sticticalis*) occurred in outbreak proportions in the western part of the state during September. They fed upon Russian thistle from Saline county westward. This situation is not uncommon in the state, but it has not occurred for two or three years.

Black crickets again became a nuisance in homes and basements during July and August. They were first reported as fully grown on June 22d at Moran (Allen county). They were probably slightly less numerous in the state and less troublesome in homes than in 1937. These insects were observed attacking alfalfa in Kansas for the first time in the history of the state. They ate the foliage in the Arkansas valley in Kearny, Ford, Finney, and Gray counties. They were reported to have reduced the seed crop in the Garden City area in

some cases 75-90 percent. Many cases of plants stripped of leaves were reported. These crickets also attacked sugar beet foliage. Poison bait sown to control them was not effective.

Blister beetles continued as plentiful or slightly more so all over the state in 1938 as in 1937. They have been recorded as 4 and 5 for almost all the state. By August 1, injury to alfalfa and gardens was reported from many parts of the state. The numbers increased until the middle of September, by which time severe damage had been done in the central and western parts of the state. Their distribution was rather general, but it reflected the distribution and large numbers of grasshoppers of previous years, the egg pods of which were severely attacked. Blister beetles were one of the major pests of the state in 1938. A half dozen species were involved during the June to October period.

Bot flies of horses were about normal in population. There was a marked reduction in number of horses in the state, particularly the western half, from various causes. Bot flies were observed ovipositing in Geary and Pottawattomie counties in October.

Book lice became numerous in September in a steel tank of wheat near Keats. The straw had lodged and the grain was wet when threshed.

Borers

The *locust borer* was reported as being exceptionally destructive during 1937 and 1938 in western Kansas.

Osage orange trees have been attacked over most of the state during the last two years by a longhorned borer (*Dorcaschema wildii*).

The *flat headed borer* continued to be a severe pest of all shade and fruit trees in 1938, including Osage orange, but the population and injury was somewhat below that of 1936 and 1937. Rains in May and June resulted in a full growth of leaves on trees in eastern and central Kansas. Trees generally suffered less from drouth and insect pests in 1938 than in the previous two or three years.

Boxelder bugs caused annoyance during warm days around homes in the spring of 1938 for the first time in five years. The population was on the rise. Numerous reports of annoyance from overwintering bugs were received during February and March. They had practically all left their winter quarters by March 25 in Riley county and became scattered. Eggs were seen on April 7. They were scarce from August on, and no letters were received about them. A small population went into hibernation.

Brown spider beetles (*Ptinus brunneus*) were sent in for the first time in recent years from two homes in the state for identification.

Butterflies

Buckeye butterfly larvae (*Junonia caenia* Hbn.) were exceptionally plentiful on "perennial snapdragons" during September at Manhattan. Some injury was done to the foliage. The adults were more abundant than usual at various flowers than for several years.

The *dwarf yellow butterfly* (*Nathalis iole* Bdv.) was exceptionally numerous in Kansas during September. The butterflies were reported at Columbus and

Labette, September 21, as gathering at flowers by the millions. Eastern collectors caught numbers of this species, which is not common ordinarily here and is scarce in eastern United States.

The *alfalfa butterfly* was plentiful in September. Both larvae and adults were somewhat more numerous than usual and the larvae contributed materially to marked foliage injury by insects to the second and third cuttings of alfalfa. These butterflies were observed to be exceptionally plentiful in western Kansas in early September, but they were largely gone by September 20.

The *mourning cloak* butterfly, also called the spiny elm caterpillar (*Vanessa antiopa*), was unusually plentiful and destructive to elm foliage, including Chinese elm, during the summer of 1938. Possibly a dozen letters with specimens were received during early June. Both larvae and adults of this species are ordinarily uncommon, but many trees with colonies of these larvae on branches were observed. The adults were no more plentiful than usual, however.

Canker worms did relatively little injury during the spring of 1938, but their distribution was markedly spotted. The moths were late in appearing in Riley county. A similar appearing halfwing (*Phigalia olivacearia*) with several other species of moths occurred in heavy flight about March 20th. Both sexes being winged, the large numbers of grayish winged moths seen particularly on March 15 and 17 and taken on bands gave rise to the early reports that there were 50 males to 1 female. However the true canker worms began emerging about the middle of March and some nearly full-grown larvae were seen May 4th on foliage on the smaller limbs of elms and hackberry trees. By the middle of May some severely defoliated elm and hackberry trees were observed from Pottawatomie, Chase and Elk counties, from the Kansas river to the Oklahoma line. Severe damage was done in Eureka, Ottawa and Howard. Many trees, and shrubbery beneath them, were completely defoliated. No banding was done at Manhattan and foliage injury was negligible, the most seen being at the country club. In the federal nurseries near Manhattan canker worms damaged young plum seedlings during April. These trees were located more than a half mile from any trees, so either the wind blew the larvae or females to the nursery or they were carried on motor cars. The larvae were largely mature by the middle of May to June 1st.

Cattle grubs were less numerous and less troublesome to livestock than for several years. They were of small consequence during 1938.

Chiggers became a nuisance about the middle of June throughout eastern Kansas. They were the subject of considerable newspaper publicity and many sulfur dustings were made against the pests. They continued abundant in Riley county until mid-September.

The *chinch bug* population was heavy only in the 12 southeastern counties, or from Coffey county east and south. Lyon, Greenwood, and Elk counties also had a fair population of old bugs. Dr. R. H. Painter observed them to be plentiful at Moran (Allen county), but scarce at Columbus (Cherokee county). They appeared in practically every field of wheat and barley in southeast Kansas during early May, where the maximum infestation was 15 per lineal foot of barley row. The young bugs began appearing about May 15

and some damage was done before the rain, May 19. They showed marked preference for barley. In some places adjoining wheat fields had few bugs in them. No injury developed to corn and few barriers were necessary during grain harvest. A fairly large population went into hibernation in the fall.

False chinch bugs (*Nysius ericae*) caused damage to spinach in Sumner county in early June. These bugs became plentiful in many fields of the state in early September.

Codling moths were the most numerous in northeast Kansas, especially Doniphan county, of any year since 1931, according to Dr. R. L. Parker. There was an exceptionally large overwintering population and many growers missed the earlier sprays because of cold, rainy weather. Larvae began entering apples about May 25th. The set of fruit was irregular and small. A large population of codling moth developed in Pottawatomie county orchards, partly because of poor spraying. For the state as a whole, the codling moth population was probably not much above normal.

Clover leaf weevil larvae were found in about normal numbers from the middle of March to June, but no injury was seen or reported. Adults appeared more plentiful than normal in local fields in June and July, but all stages were scarce in the fall.

The *tropical* or *banded cockroach* (*Supella supellectilium* Sev.) has become established in Kansas. A residence and an apartment house had small colonies during the fall of 1937 and spring of 1938 at Manhattan. This was the first report for Manhattan, but Lawrence (1938) observed it as early as 1933 at Fort Leavenworth. Specimens were received also from Pratt and Abilene, where homes were infested with this species.

Corn bill bugs were less numerous and less destructive in the lowlands and creek bottoms of southeastern Kansas than for many years. Rotation and tilling have reduced the species.

The *corn earworm* was perhaps a little less numerous and destructive in 1938 than normally. Dr. R. H. Painter determined that the infestation of corn at the agronomy farm was between 98 and 100 percent, but the extent of damage was a little less than last year. Damage to sorghum heads during September was probably a little more common and severe than normal. However, corn earworm moths were fully as plentiful at lights during the fall as in previous years.

Corn root worms have had populations below normal during the drought years. The abandonment of corn for wheat, barley and other crops has reduced their food.

Cotton moths (*Alabama argillaceae*) appeared in numbers equal to the heavier flights of recent years at the lights during September and early October.

Crambid moth flights (largely *Crambus vulgivagellus* Clem.) during the spring and fall were striking features of 1938. The extraordinary fall flight began about September 20th and continued to about October 8, when the moths disappeared rather suddenly. This heavy flight was observed in Smith, Jewell, Republic, Washington, Cloud, Clay, Ottawa, Saline, McPherson, Harvey, Sedgwick, Cowley, Marion, Dickinson, Geary, Pottawatomie, and Riley counties. The moths occurred in greatest numbers in grass and came to lights, especially the blue neon lights. They have not appeared in greater numbers for many

years. Some skeletonizing injury to young, fall sown alfalfa early in October was probably due to young crambid larvae.

These larvae, possibly assisted by *Nomophila noctuella,* destroyed 40 acres of blue-grass and wild-oat pasture at Williamsburg, Kan., in April. The larvae made a webbing around the base of the plants, but ate the vegetation completely and moved on. The larvae wintered where there was a thick protecting mat of old grass. C. J. Ward, of Coats, Kan., reported finding 46 larvae in 3 shovels of injured buffalo grass sod. The first generation of larvae became prepupae and pupae in their tubes about July 1, and moths appeared soon after.

In Riley county a large collection of what was thought to be *Nomophila* larvae was made, mostly in June, but when the moths appeared they were all crambids. Most were of the species mentioned. The larvae were dug from a grassy alfalfa field, as many as a dozen being dug from around one clump. It is possible that some previously recorded injury attributed to *Nomophila* may have been due to crambids.

Striped cucumber beetles reached destructive numbers about June 20th and from then on till the end of season did severe injury. The experimental plot of cucumbers was finally abandoned because of drought and these pests, accompanied by the wilt disease which they carry. By August there was a general outbreak in the state, particularly in the Kaw valley. The wilt disease was particularly severe in 1938.

Cutworms in general were widespread, but most species did not reach outbreak proportions. The one exception was the pale western cutworm whose outbreak was a feature of 1938. The severest injury to gardens, particularly cabbage and tomatoes, occurred in northeast Kansas during May, according to Dr. R. L. Parker.

Army worms (*Leucania unipuncta*) were in outbreak in parts of Texas (Waco) and Oklahoma during early May and reached damaging numbers in southeastern and southcentral Kansas about May 15th. They ate the leaves, beards and some kernels from wheat, rye and both winter and spring barley, particularly in southeastern Kansas. Farmers called them "cutworms" or "army worms." Army worms and the wheat head army worm or "barber worms" attacked the heads of the heavier stands of wheat from Osage county south the latter part of May and early June. Injury was greatest in the lodged wheat. Braconid parasites were exceedingly numerous, the ground in places being conspicuously dotted with their white cocoons and many were sent in for identification of those "white eggs." Tachinid parasites and a disease also killed many of the larvae. Both species of larvae occurred in wheat fields all over eastern Kansas, especially northeast Kansas. The army worms occurred in more than normal numbers, but little or no apparent injury was done other than in the southern half of the state. The moths began appearing at lights in normal numbers about June 20th.

Army cut worms (*Chorizagrotis auxillaris* Grote) were numerous, especially in northwestern Kansas, but not destructive during the spring of 1938. Their population was about normal and above that of 1937. Mr. H. H. Walkden ranked this species at 2 for Riley county and second in abundance in pastures. In addition to grassland, the species was readily found in alfalfa fields and it damaged oats in Pottawatomie and Republic counties. Parasites and disease

caused a heavy reduction of all species of cut worms, even the pale western by June 1st.

Cotton cut worms (*Prodenia ornithogalli*) were slightly more numerous on young and old alfalfa, weeds, and some garden plants in 1938 than in 1937. Some injury done by this species in Riley county and perhaps eastern Kansas was ascribed to other cut worms, especially the cotton worms and army worms. This was the case of an "army worm" outbreak reported in the newspapers September 21 at Hutchinson though *Scotogramma trifolii* was also present.

Fall army worms were again numerous enough in eastern Kansas to do damage to corn in some fields. The population was about normal and perhaps below 1937. A 35 acre field of corn in Geary county, planted July 8th, had the tassel or curl of every stalk infested and severely damaged by these larvae. The field was visited August 23. Alfalfa, corn and sorghum fields near by had few or no larvae in them. Heads and curls of Kafir on this farm were heavily attacked but sorghum plants were only lightly attacked. Late sweet corn in Riley county was severely attacked by this species.

The *pale western cutworm* (*Agrotis orthogonia* Morr.) occurred in the "most severe outbreak yet recorded in Kansas," according to Mr. H. H. Walkden, who observed "damage in 13 counties, of which Thomas, Gove, Lane and Ness counties had the most severe damage, which was confined to wheat, and to one stand of alfalfa." The other 7 counties were Rawlins, Decatur, Sheridan, Logan, Trego, Ellis, Rush, Ford and Meade. The population was larger and more widespead than in 1937. Mr. Charles Curtiss reported an unusually heavy population of this cutworm in wheat fields at Liberal (Seward county). It is probable that this cutworm was present in more than normal numbers from these counties west to the Colorado border. Mr. Walkden reported that they did little or no damage to fields of wheat which had been full season fallowed.

The *clover cutworm* (*Scotogramma trifolii*) was again somewhat more plentiful on weeds and alfalfa than normal in central and western Kansas. Injury was done to young alfalfa southwest of Manhattan (Riley county) the middle of September, by this species. Similar injury at Wakefield, and at Ellsworth was probably done by this species and some corn ear worms.

Mr. H. H. Walkden, of the local laboratory of the Bureau of Entomology, a specialist on the noctuids, supplied the following observations on the less well known species of cutworms: the clay backed cutworm (*Agrotis gladiaria* Morr.) was the most abundant species in pastures during March and April, especially where little barley was present. He scored the species at 3 for Riley county. The dusky cutworm (*Agrotis venerabilis* Wlk.) was abundant in pastures, lawns and gardens. It was scored at 3 for Riley. These species ordinarily succeed the army cutworm and precede the variegated. This latter species was scarce in the state in both alfalfa and sweet clover where it generally occurs.

The shield-marked cutworm (*Rusina bicolorago* Gn.) was more plentiful than ever before observed in Kansas. Previously it has been a rare species but in 1938 it did some damage to garden crops, especially in Doniphan county. Mushrooms are its favored food. The species was scored at 3 for Riley county.

The bronzed cutworm (*Nephelodes emmedonia* Cram) appeared a month

earlier than usual and became abundant in blue grass plots in early April. The population which was scored at 2 was decimated by wilt disease, leaving few survivors.

The dark-sided cutworm (*Euxoa messoria* Harr.) a northern species usually rare in Kansas, was fairly common in the northwestern counties of the state and a few specimens were taken in Riley county.

The yellow army worm (*Leucania phragmatidicola* Gn.) and the black cutworm (*Agrotis ypsilon* Rote) were scarce. A few specimens of the former were taken in pastures.

The dingy cutworm (*Feltia subgothica* Haw.) was less abundant than in 1937. It was scored at 2.

False wire worms (*Eleodes opaca*) attained a large population in all counties west of Dickinson and Sumner to the Colorado line, where they destroyed thousands of acres of wheat. The larvae were found in great numbers by the middle of April and caused large brown spots in the wheat fields. Many farmers disked such fields to comply with the Agricultural Conservation Program. The larvae began pupating by the middle of April which was possibly two weeks early. The adults of this and the western species (*E. coloradensis*) were more plentiful than usual from May 20th under all kinds of cover.

These pests again attained a large population and destroyed considerable wheat during the fall (September and October). These observations were made in Cowley, Butler, Saline, Dickinson, Harper, Pratt, Kingman and Clay counties. Replanting was necessary in many fields. The unusually dry upper six inches of soil and lack of rain in the long, warm fall favored these pests and was unfavorable to wheat.

Eight spotted forester moth larvae were common on grape and woodbine during May. The population of this species was larger than usual. The moths were plentiful from May 20th.

Fleas developed in basements in about the usual number of homes during the year. There were more reports during late summer than earlier.

Biting flies on livestock flies were distinctly below normal in 1938. They were most numerous during August and early September. Horn flies were more numerous locally than stable flies. This appeared to be true in southeast Kansas counties and Pottawatomie, Lyon, Chase, and contiguous counties the middle of May. Horse flies (*Tabanids*) were of small consequence and below normal.

House flies were also less numerous and annoying than usual.

Screw worm flies (*Phormia* and *Chrysomyia*) were again numerous and annoying in Kansas. Veterinarians were said to have had more cases of this parasitism than for several years. An infested calf in Comanche county was seen as early as March 21st. During April and May, there was a small outbreak of these pests in southeast Kansas on dehorned and castrated cattle and sheared sheep. Woodson county appeared to have had the largest number of cases, but these pests were severe in Elk, Butler, Chase, Coffey, Montgomery, Wilson, and Bourbon counties also. The screw worm menace continued through September. Cowley had many cases of wool grubs in sheep during the year.

Grasshoppers were again more numerous than usual and in outbreak over all but the eastern third of the state, although the population was distinctly below that of 1937. A relatively large population of eggs survived the mild, dry winter of 1937-'38 in excellent condition. Marked injury to the borders of wheat and alfalfa fields during the fall of 1937 was seen in Clark, Barber and Comanche counties. Hatching began about April 1, though third and fourth instar nymphs of *Chortaphaga* were fairly common in Riley county the middle of March. Young hoppers were seen in Riley county on April 8, in Barber county on April 12 and Clark county on April 15. Spring came fully two weeks earlier than normal and these eggs hatched two weeks early. By May 3 it was estimated that 30 percent of the eggs had hatched and by June 1, 85-90 percent had hatched. The blizzard of April 8 and rains of early May did little injury to the young hoppers. By the middle of May nymphs were as numerous in Riley county as has ever been seen. By the middle of June their distribution was variable and both the fungus and possibly a bacterial disease began checking them materially.

Parasites began to be effective at the southern border. By the latter part of June hoppers were still scarce in all but a few fields around Manhattan, but by July 1 some fields showed injury, and control measures were necessary. The two-lined species *Melanoplus bivittatus* was the most numerous then, more than half being mature. The heavy vegetation in waste places provided them with food and thus kept them out of wheat, oats, corn, and alfalfa fields to a marked degree. Excellent kills with poison mash were obtained, the average net kill in 14 test sowings being 78 percent. Parasites continued to be a limiting factor all season, and a disease thought to have been bacterial was noticeably effective. The differential species was slow to build up, the two-lined predominating all over central Kansas, but *Aelopus turnbulli* dominated in early July in western Kansas. The migratory species (*M. mexicanus*) was widely distributed and the most abundant species for the year, according to the federal survey. By August 1 grasshoppers were no longer a menace in Riley county. In the western part of the state, however, grasshoppers continued to cause damage in many counties. Corn was severely injured in Decatur, Norton, Phillips, Smith, Sheridan, Graham, Osborn, Cheyenne, Sherman, Jewell, Washington, Republic, Ness, and Cowley counties. A second generation of the migratory species began injuring fall-sown wheat the latter part of September. In Marion county strips of wheat two drill widths in extent were largely destroyed in many fields.

In general, severe injury in eastern Kansas was averted by the large amount of green food other than crops available to the hoppers and the population was markedly reduced in the late summer and fall by good control results with poison bait and by natural enemies such as *Sarcophagids,* mermids and disease. Hoppers were not abundant in the late fall and eggs, while readily found, were slightly fewer than in the fall of 1937, except in certain areas in the western third of the state. Only in Greeley and Logan counties were egg beds described as "heavy." The long, warm fall made possible the complete oviposition by all normal female grasshoppers.

Paradalophora adults came to lights about the middle of June in more than normal numbers. Another feature of the year was that *Aelopus turnbulli,* which damaged wheat by cutting off the heads in western Kansas possibly for

the first time, has never been studied. *Dissosteria longipennis* was again fairly common in western Kansas and specimens were taken as far east as Smith Center.

The following figures are taken from the 1938 annual report of the extension entomologist and indicate something of the population of hoppers during the year. Grasshopper control was carried on in 103 counties by 56,645 farmers, who sowed 13,989,388 pounds of poison bait on 2,225,335 acres. Acres tilled to destroy eggs in the fall of 1937 were 506,952, and 122,890 idle acres were cultivated during 1938. There were 598 hopper dozers and 658 bait spreading machines used.

Hessian fly had the lowest population for the species for many years and did not attain destructive numbers in the state either during the spring or fall. The largest population developed during the spring in southeast Kansas, but even there only occasional fields were lightly infested. A large acreage of the wheat was sown on or after the fly-free date during the previous fall, and much of the wheat was Kawvale, a fairly resistant variety. The laboratories of the Bureau of Entomology at Wichita and Manhattan determined by actual counts at harvest time that the average infestation in northeast Kansas was 3 percent, the maximum 56 percent; for southcentral 3 and 26 percent, for southeast 5 and 28 percent.[3] There were two spring broods which has not occurred for many years, in 1938, utilizing late tillers.

There was much volunteer wheat during August, and Hessian fly developed rapidly, but the exceptionally dry fall was unfavorable and the fall-sown wheat was lightly infested, and that only in certain fields. Dr. R. H. Painter found a maximum of approximately 50 percent of plants infested near Iola and 30 percent near Yates Center. About the middle of November various sized larvae were found in Dickinson county, including newly hatched ones after the rain of early November. Wheat came up poorly. The stands were spotted, depending upon the amount of soil moisture present, and the outlook at the close of the year was the poorest for many years. The best wheat sections in the state in the order named were southwest Kansas, southcentral, central, northeast, and eastern Kansas. Mr. E. T. Jones, of the Bureau of Entomology and Plant Quarantine, reported that of 36 fields examined for fly during the late fall, 33, or 92 percent were infested, the number of farms per infested plant ranging from 1 to 2.7 with 2.1 being the average. These plants were from selected early sown fields in Waubaunsee, Morris, Lyon, Coffey, Osage, Shawnee, Pottawatomie, Riley, Geary, Dickinson and Leavenworth counties. Apparently many stubble "flax seeds" as well as larvae of all sizes went into the winter.

Leafhoppers were exceptionally numerous on spirea, elms and many bushes in Riley county in April and May, (*Erythroneura*) on alfalfa and potatoes from June to August, on elms, grapes, woodbine, and Virginia creeper during August and September and at lights during October. They were a great nuisance at lights, especially around neon lights during October and in stores and theaters. Several species were included in the swarms but *Polyania inimicus* was the dominant one. The long, warm, dry fall kept them active and out of hibernation. Elm foliage was severely injured by *Erythroneuras*.

3. Insect Pest Survey, Bureau of Entomology and Plant Quarantine No. 7, p. 516, September 20, 1938.

The leaves of many trees, grapes and other vines were often whitish. Their feeding effects were intensified by the exceptionally dry weather. Hopper burn on potatoes was common in early July. These insects were more numerous than in 1937 and they persisted longer.

Lice on domestic animals, both biting and sucking species, were less numerous and annoying than usual. Cattle infestation occurred, however, in almost every herd examined in Clark county the middle of April, and more than a hundred cattle "died following dipping of several hundred on April 6th and 7th on the Campbell ranch." Practically no correspondence regarding these parasites was received during the year. There has been marked reduction in the number of domestic animals in the state, particularly in the western half. This accounts in part for the low population of parasites of animals.

Maple worms were in local outbreak in Cloud, Clay, Jefferson and in nearby counties. Many completely defoliated trees were noticed on a trip from Topeka to Atchison about the middle of July.

Mosquitoes were more abundant in Kansas from early September to early October than for several years. They were relatively scarce in June and July in spite of a wet May and June.

They were not an annoyance anywhere during the early part of summer, though the numbers were building up. But they were annoying all over eastern Kansas during September and October. One could scarcely work in the gardens in the evening in Riley county, and egg rafts were more readily found than for many years. Newspapers reported that apple pickers were driven from the orchards in Jackson and other northeastern counties.

Equine encephalomyelitis developed again in serious outbreak in Kansas and the Great Plains. Dean R. R. Dykstra, Division of Veterinary Medicine, reported 16,257 cases in Kansas, with a mortality of 16 percent against a mortality of 47 percent for all the states. The peak was reached the latter part of August and the number of cases declined rapidly in September. A coöperative research project on arthropod transmission was begun in September at Kansas State College. Many persons believe the prevalence of mosquitoes was responsible for a reoccurrence of this disease.

Mites

Clover mites invaded homes in Riley and Jefferson counties in April in large numbers and caused annoyance. Apparently a great number of eggs of this species passed the winter of 1937-'38.

Brown mites on wheat were reported in more than normal numbers around Hutchinson and southward in early May. Wheat in spots was made yellowish but not severely injured.

Red spiders were present in early May in Riley county, but were largely controlled by rains until the latter part of June when they were observed again in normal numbers. Many elms were attacked during July and August, as was indicated by the marked salmon-brown foliage. The attack came late, and only weakened trees showed marked foliage injury. These mites persisted on trees and vines to mid-September. They injured late beans, and garden flowers and were abundant on some weeds. Less than normal damage, however was done during the year.

Negro bugs began accumulating on Coreopsis at Manhattan, May 2, and reports of injury to cherry (probably incorrect) were received. These insects also attacked snapdragons. They continued abundant on *Coreopsis* in Riley up to mid-October.

Onion plant bugs began congregating on onions by May 1 in Riley, Marshall and Cowley counties, and there were indications of an outbreak. Rains in early May reduced their numbers markedly and by June 1 the bugs were largely gone. They did little or no damage in 1938. Onions grew nicely following the rains and a good crop was harvested. The bugs appeared to cluster somewhat on lettuce and radishes also.

A pentatomid or "stink bug" (*Thyanta custator* Fabr.) was reported in unprecedented numbers at lights in Kansas on the night of October 14. At Leonardville they came to the lights on a football field in such numbers that the game was temporarily stopped. At Clay Center the dead bugs were gathered up with scoop shovels and two truck loads hauled away. (See Topeka *Capital,* October 23, 1938, p. 2B.)

At Lincoln Center oil was poured on the piles of bugs to burn them. J. H. Williams, of Wilson, stated that the bugs appeared there and nearby towns in such large numbers as to collect in piles. They appeared to come from the north, flew against the building and piled up on the sidewalks or awnings. One awning collected more than a bushel of bugs. Many burned the piles with gasoline and oil. At one street intersection the pavement was covered with them. At Elkhart traffic was stopped. A study of the points reporting these flights lie on a straight line from Elkhart in the southwestern part of the state to Hiawatha, Kan., in the northeast, as pointed out by Wilbur (1939). State Meteorologist Flora stated that "this line may possibly have been the meeting point of two air currents, a cooler current aloft from the northeast and a warmer current from the south beneath, causing the bugs to descend."

This pentatomid is the commonest species of the family in the state. It overwinters as an adult and the long, warm fall delayed their going into hibernating quarters.

Polistes wasps were again abnormally pentiful during the fall of 1938, the population in Riley county being about the same as in 1937.

Poultry pests, particularly, mites, lice and bedbugs continued at about the usual level of annoyance.

Sawflies

The *American sawfly* (*Cimbex americana*) was more numerous in Kansas during June and July than for many years. There was a notable amount of correspondence on the subjects with specimens submitted. They attacked elms, chiefly, and occurred widely over the eastern half of the state, but were not abundant nor destructive anywhere.

Rose slugs did considerable injury to rose foliage in eastern Kansas during May. The wasps appeared in Riley about April 23 but the distribution was spotted. The population and injury was probably less than normal. More than usual trouble was experienced with rose mildew by early June, because of rains and cool weather.

The *common stalk borer* (*Papaipema nebris*) was more plentiful and destructive during 1938 then for several years. The larvae were common in stalks of field and sweet corn. They were also taken in castor oil plant stalks. This same species, locally called the potato stalk borer, caused severe injury to tobacco seedlings and transplants in Doniphan county in May according to R. L. Parker.

Another stalk borer (*Mamestra picta*) was reported as destructive on red clover in Allen county in early May. This species had not been seen in the state for many years.

Silverfish were more numerous and troublesome in homes than usual. An unusually large number of reports of their presence came in all year, but particularly during September and October.

Sphinx sp., reported last year as *Hyloicus drupiferum* (wildcherry sphinx), was probably not correctly named. The black and white moths again appeared at cherry blossoms the latter part of April, reaching a peak in early May. Many of these moths were collected by students in 1937. Sphinx larvae which were fairly common on woodbine in May might have been this species.

Stored grain insects increased in population and damage in 1938, according to Dr. R. T. Cotton, of the Manhattan laboratory of the Bureau of Entomology and Plant Quarantine. He stated further that "with the return to more nearly normal weather conditions in 1938 the damage to stored grain in Kansas from insect attack has increased noticeably. Inspection records of grain arriving in the Kansas City market indicated that insect infestation during the season was not much less than for the season of 1932-'33, when damage from insects was extremely severe.

"Surveys of farm-stored grain in the vicinity of Manhattan revealed a rather general infestation. The insect most prevalent is the cadelle, although the flour beetle, the flat grain beetle, the Indian meal moth and, in some bins, psocids, have been found in considerable numbers. This condition can probably be accounted for by the higher moisture content of the grain which renders it more attractive to insects and more suitable for breeding." The foreign grain beetle attacked corn in the field according to Professor G. A. Dean during the fall and winter of 1938.

The largest population of *strawberry leafroller* occurred in northeast Kansas, according to Dr. R. L. Parker, since 1932 or 1933. Frequent rains allowed only a short period of 5 to 7 days for spraying, and many growers failed to carry out the spraying schedule. There was considerable injury, but wet weather enabled the plants to produce some berries, and there was a short crop generally.

The *strawberry weevil* (*Anthonomus signatus*) broke out again in a small area in northeast Kansas according to R. L. Parker in 1938. The *strawberry sawfly* in a local area in Doniphan county did considerable injury to strawberry foliage this spring according to Doctor Parker.

The blue grass *Sphenophorus* was markedly more numerous and destructive during the spring of 1938 than in 1937, according to Professor D. A. Wilbur. All stages of this small snout beetle were dug up in grass plots and lawns at Manhattan while adults ate the crowns and were numerous on the sidewalks. These beetles are widely distributed in the state.

Sheep head maggots were more numerous and destructive than usual. The species had built up during 1937 and much injury was observed during the spring of 1938.

Squash bugs were in outbreak in 1938 and more destructive than for several years. The old bugs hibernated in somewhat larger numbers than usual and were active in early March. By July 1 they developed to the point of an outbreak and became one of the major truck pests of the state. They killed the squash, melon, and pumpkin vines in the Kansas valley. They destroyed about 30 hills of pumpkins in the experimental plot in spite of daily collections of 75-100 adults under shingles and frequent insecticidal dustings. They attacked cucumbers, cantaloupes and watermelons, also. The hot, dry summer intensified the injury of the bugs. They received some newspaper publicity under the name of pumpkin bugs.

Tanymecus confertus Gyll., a medium-sized snout beetle, was taken March 28 in a greenhouse at Topeka in numbers. It was reported doing damage to greenhouse plants.

Termites were fully as numerous and did more damage in 1938 than in 1937, but there were fewer swarms in homes and more injury to trees and growing plants. Termites swarmed in large numbers following rains March 10-12, and in early April and May. Correspondence and observations during the spring indicated the usual population. Colonies throughout April and May showed many soldiers in the burrows, indicating that they were ready to swarm when rains came. Tree injury occurred widely in the state in the late summer and fall.

The *tomato horn worms* were perhaps slightly less numerous on tomatoes during the fall, September and October, than usual, and as would be expected in a long, dry, warm fall. Relatively few larvae and no serious injury to plants were seen. About the usual number of moths, however, came in for identification.

The *wheat stem maggot* (*Meromyza*) had about the normal population in Riley county. Little injury was done.

The *wheat straw worm* had one of the largest populations in the 1936-1937 wheat crop in Riley county that occurred in recent years. The adults appeared in September in large numbers.

Wheat white grubs (*Phyllophaga lanceolata*) developed into the largest and most severe outbreak during the fall of 1937 and the spring of 1938 in 10 years or more. The junior author estimated that 500,000 acres of wheat in what is called by Gates (1937) "the mixed bluestem area of the state" were destroyed. The severest injury, which is cutting off the plants, occurred in and around Sedgwick county, but it extended to Cowley on the east and Clark on the west. The species has gradually extended its range northward, due to the dry weather, to Morris, Riley and Cloud counties, where they were plentiful in 1938. Many fields were reseeded as many as three times, while others were put into oats or barley or summer fallowed. Some farmers disked the fields and used this areage to comply with the agricultural conservation program regulations. Mr. H. H. Walkden observed a 40-acre wheat field at Glasco which was destroyed, and when planted to barley in the spring the crop was again severely damaged by larvae of this insect. Most infested land has been

cropped continuously in wheat for four or more years. The year 1938 was the beetle year of the two-year life cycle, and the adults were proportionally abnormally abundant, even in Riley county. However, grubs of this species were common, showing overlapping of broods, but the larvae have been more or less destructive in the odd years since 1907.

White grubs were numerous in gardens and lawns during the spring and summer. Early summer rains, however, were favorable to development of lawns and grass.

Carrot beetle adults were exceptionally plentiful in fields and gardens in the spring. Any digging was likely to turn up adults. More specimens were sent in for identification than for several years.

Wireworms in general were not particularly numerous or troublesome. Professor H. R. Bryson reported injury in scattered small areas of wheat by *Aeolus elegans* in Riley and Geary counties.

Web worms occurred in central Kansas during September and caused considerable damage to young alfalfa. This injury was pronounced in McPherson, Marion, Reno, Harvey and Sedgwick counties. The species involved is not known for certain. Some specimens of *Scotogramma* were sent in, but they do not do much webbing ordinarily. It is believed that they were assisted by the garden web worm and possibly by some crambids, though it has not been established that the latter feed on alfalfa sufficiently to destroy it.

SUMMARY AND CONCLUSIONS

The year 1938 was the eighth in the drouth cycle beginning in 1931. Precipitation during the year from April to August was normal or more, but drouth conditions prevailed in the state during the spring, and extreme drouth from September until the close of the year, particularly in central and eastern Kansas.

The following insects were in *outbreak* in 1938: apple grain aphid, melon aphid, beet web worm, blister beetles, flat headed borer, crambids, striped cucumber beetle, army worm, pale western cut worm, grasshoppers, squash bug, wheat white grub. The following forms and most of those mentioned above were *more numerous* than in 1937: pea aphid, redbud aphid. locust borer, boxelder bug, mourning cloak butterfly, canker worm, chinch bug, codling moth, army cut worm, clover cut worm, false wire worm, screw worm flies, Hessian fly, leaf hoppers (*Empoasca* and *Erythroneura*), maple worm, mosquitoes, polistes wasp, American sawfly, rose slug, common stalk borer, silverfish, stored grain insects, strawberry insects, sheep head maggot, wheat straw worm, and web worm.

The following species were approximately *as plentiful* as in 1937: ants, green bug, bagworm, black cricket, bot flies, clover leaf weevils, cotton cutworm, onion plant bug, poultry pests, sphinx moths, termites, wheat stem maggot, white grub, carrot beetle.

The following species were scarce or *practically absent* in 1938: corn leaf aphid, corn root aphid, corn root worm.

The following species, in addition to the above, were *less plentiful* than in 1937: cattle grubs, corn bill bug, corn ear worm, fall army worm, biting flies, house flies, biting and sucking lice, tomato horn worm, wireworms.

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Monument Rocks, Gove County, Kansas

GEOLOGY

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On October 7, 1938, the monument Rocks were surveyed to give a general description of the geology and the plant and animal life of the area.

The Monuments (Pyramids) are small castellated buttes, 40 to 60 feet high. They occur in the Smoky Hill member of the Niobrara formation. Erosion has cut them off more in some places than in others. For the most part they are capped by massive chalky limestone, 8 to 10 feet thick, which weathers a dull, ocherous yellow. On some exposures, especially on the southern faces, this upper portion has a wind-erosion veneer. Much of the upper portion is quite dark due to lichen growth. Below the massive upper layer come chalky shale and chalk, then a bluish chalky shale. Large, flattened, circular limonite concretions occur in various layers below the upper hard limestone. Many of these concretions have incorporated in them portions of large Pelecypod shells (Inoceramus?), more or less replaced by the iron. Often these concretions when broken open have yellow and black powder, probably weathering products of iron sulfide. Near the base of the buttes are numerous layers made up of crushed Inoceramus shells, in many instances clusters of small oyster shells coating portions of them.

The strata are nearly horizontal. The more northerly portions show a slight dip to the north. In other places there is a slight dip to the south, but not consistent enough to justify one in suggesting a slight anticlinal structure. There has been some local faulting, in one case with a throw of nearly three feet. In most cases the throw is very slight and there are a good many joints showing no faulting. Some of the faults and joints are fissured and the fissures filled with carbonate which has not crystallized, probably weathered from upper strata and washed into the fissures. Some fissures have thin layers of crystalline gypsum and there are a few horizontal bands of the same material. The lower portions of the buttes have the slope covered by debris except for the more exposed sides where wind and water have cleared it away.

These buttes are erosion remnants, like the many vertical bluffs of the plains region. Practically horizontal strata in a semiarid climate tend to weather and erode into vertical forms, especially if strata of varying degrees of hardness occur. Some exposures to the east of the group give one a good clue to the mode of origin, in fact, make that area a good demonstration. Possibly originally the bluffs were cut by the Smoky Hill river, on whose old flood plain they now stand. They may mark out part of an old meander pattern. Once cut as bluffs, gullying could and probably did sculpture the remainder. Torrential rainfall with its very rapid runoff breaks through the resistant layers at various points. Often these breaks are "accidental," animal burrows, denuded spots, slight pockets of less resistant rock, depressions of one sort or another which concentrate the runoff. Once such a break has occurred,

Trans. Kansas Acad. Science, Vol. 42, 1939.

the runoff will be concentrated into the gulleys, with consequent headward erosion. Any differences in hardness or slope, any breaks, will tend to alter the direction of this headward growth, and successive rains will add their share to the cutting. Since a gulley drains most of the runoff from its immediate vicinity, there will be left between gulleys areas which are being less severely eroded. Once gulleying has worked headward until two or more gulleys become confluent, the combined stream beds become temporary streams, and cease to cut as gulleys. Laterals will develop from these streams, gulleying at angles, but the streams themselves will deepen and widen their beds, thus bringing a greater separation between the erosion remnants. Possibly they may divert the main stream channel or a portion of it, thus gaining greater force for their widening.

Gulleying will continue to act from these streams toward the new bluffs, and they in turn will be dissected. This will divert more of the runoff from the first set, and with an ever changing drainage pattern which is growing away from the erosion remnants there comes a time when practically all the water erosion which cuts these is due to the rainfall on their own limited surfaces. The effect of this is readily seen on the larger pyramids, which are becoming dissected by it.

At the base of one of the buttes a small iron sulfide concretion of the "pop-rock" type was found, apparently in place. Few fossils aside from the Inoceramus and oyster shells were found. One shark tooth was picked up.

One is impressed by the dust-laden wind in the region and is tempted to give to wind erosion more credit than really due. Wind blows away the weathered rock, picks up loose material in crevices, to some extent cuts, with the aid of sand. This is, however, only a minor feature of the erosion.

A rather striking profile has eroded out on one of the smaller buttes, and is referred to as Old Man Smoky. The question has been raised by some of preservation of this profile. The Old Man of the White Mountains, made famous through Hawthorne's Great Stone Face, has been tied together somewhat, as spalling off threatened to destroy the profile, but that face is carved in granite. A profile carved in relatively soft, chalky limestone and shale presents a different problem, and the only way in which it could be preserved is, I fear, by protecting it from erosion.

VEGETATION

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There are relatively level areas capping the hills at some distance from the pyramids. These areas are generally fairly well covered with buffalo grass (*Buchloe dactyloides*), blue grama grass (*Bouteloua gracilis*), and various other less important species of grass and forbs. The ground lying immediately around the pyramids, however, is rough and the mantle of black soil characteristic of the better land in this region has, in most cases, been completely eroded away, leaving only badly disintegrated fragments of limestone to support the bunchy, sparse vegetation. The landscape from a distance reminds one of the sagebrush farther west. Closer examination, however, reveals the shiny, bunchy condition to be caused by occasional plants of four wing saltbush (*Atriplex canescens*), winter fat (*Eurotia lanata*), and eriogonum (*Eriogonum effusum*).

These bunches of xeric forbs are intermixed with individual plants of side-oats grama (*Bouteloua curtipendula*), hairy sporobolus (*Sporobolus pilosus*), wire grass (*Aristida longiseta*) and (*Aristida purpurea*), and little bluestem (*Andropogon scoparius*).

Among the grasses and forbs found were the following:

Grasses

Blue grama grass (*Bouteloua gracilis*)
Buffalo grass (*Buchloe dactyloides*)
Sand dropseed grass (*Sporobolus cryptandrus*)
Saltgrass (*Distichlis stricta*)

Forbs

Broomweed (*Gutierrezia sarothrae*)
Broomweed (*G. linearis*)
Spiny sideranthus (*Sideranthus spinulosus*)
Blazing star (*Liatris punctata*)
Yucca (*Yucca glauca*)
Many-flowered aster (*Aster multiflorus*)
Salmon-colored mallow (*Malvastrum coccineum*)
Scarlet gaura (*Gaura coccinea*)
Evolvulus (*Evolvulus pilosus*)
Narrow-leaved tetraneuris (*Tetraneuris stenophylla*)
Prairie false boneset (*Kuhnia glutinosa*)
Fendler's aster (*Aster fendleri*)
Needle-leaved gilia (*Gilia acerosa*)
Purple prairie clover (*Petalostemon purpureus*)
Few-flowered psoralea (*Psoralea tenuiflora*)
Stanleya (*Stanleya pinnata integrifolia*)
Racemose milk vetch (*Astragalus racemosus*)

FAUNA

L. D. WOOSTER, Ft. H. K. S. C., Hays, Kan.

The animals of the Monument Rock area are largely those of semidesert and the Lower Sonoran life zone.

Typical mammals are coyotes, striped skunks, spotted skunks, thirteen-lined ground squirrels, black-tailed jack rabbits, cottontail rabbits, and kangaroo rats.

Among the birds found there are golden eagle, American eagle, American rough-legged hawk, ferruginous rough-legged hawk, marsh hawk, Swainson hawk, great horned owl, monkey-faced owl, prairie horned lark, meadow lark, and along the river, great blue heron.

Representing the reptiles in considerable abundance is the prairie rattlesnake.

The Brachiopod Genus Enteletes, With a Description of a New Species

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When on the geological records, a new genus appears, which becomes a horizon marker, used as an index for dividing geological time, the student seeks to learn the characters of the species included under a generic name, the range of the genus in the geological column, and an explanation of how it may have come into being.

And if God works the same, "yesterday, today and forever," one cannot disregard the laws of heredity that have become generally known only within recent years, in interpreting the possibility of origin.

There are interlocking problems in classification, identity of geological formations and the character of fossils due to the nature of preservation, *i.e.*, the conditions under which sedimentation took place, which must be considered and uniformly worked out before the final words can be spoken in classification of known fossils, their horizons definitely established, and before a complete correlation of strata can be established.

In the genus *Enteletes*, and the literature on the subject, these problems appear:

1. Should the same name be applied to a fossil during its entire life history? Some brachiopods now have different specific, generic, and even family names applied to them at different stages of development.

2. Should difference in size, other relations being proportional, be the grounds for separation into species? Some say "yes"; others, "no."

3. Where does individual variation cease and specific difference begin? If each specimen having a describable difference is described as a new species.

4. What allowance must be made for variation of form due to horizontal, lateral and oblique pressure? Since each outcrop usually consists of beds representing minor elevations and subsidences of the ocean bottom in relation to sea level, thereby changing the nature of the materials deposited, there may be a decidedly different effect on the future shape of the fossils at different elevations in the same general horizon. Fossils in soft deposits change shape with consolidation.

The consolidation, being so gradual, there may be no visible sign of any break at all in the shell texture and the change could not be known at all except for the position of the fossil in the rock, which indicates the direction of the force which produced distortion. These cannot be considered as separate species.

In "The Brachiopoda of the Pennsylvanian system of Nebraska," 1932, Dunbar and Condra give the following synthetic diagnosis of the genus:

"GENUS ENTELETES. Fischer de Waldheim. 1825"

"*Diagnosis*. Strongly biconvex orthoids with strong subangular plications arising on the umbones and extending to the anterior margin. Dorsal valve somewhat the larger, with its medial plication enlarging into a fold; ventral

Trans. Kansas Acad. Science, Vol. 42, 1939.

valve with its median sulcus enlarged into a sinus to match the dorsal fold. Hinge line short, cardinal areas small, beaks more or less strongly curved. Entire surface covered by fine radial lirae. Shell punctate."

"Internally: ventral valve bears three strong subparallel septa; the median one begins low in front of the beak and increases to a great height a little behind the mid-length of the shell where it is steeply truncated; the lateral septa are extensions of the strong dental lamellae, which reach the floor of the valve and extend with gradually decreasing height to near the middle of the valve. In the dorsal valve the greatly extended crural plates form a pair of short diverging septa. Muscle scars are faintly impressed."

"GENOTYPE: *Enteletes choristites,* Fischer de Waldheim."

As above stated, the diagnosis, if technically construed, might exclude *Enteletes pugnoides* of Mr. Newell and the new species I will describe as having two minor plications in the median sculcus of the ventral valve and three on the median fold of the dorsal. I propose to restate the diagnosis so as to include the whole life history of the members of the genus under one description and in terms of growth.

GENUS ENTELETES, Fischer de Waldheim, 1825.

Theoretically bisymmetrically biconvex orthids, which develop within varying distances from the hinge line radial plications which increase in size to the periphery. In the earlier stages the form of the shell is biconvex, almost disclike, with fine radial striae about five to one millimeter, but having no plication. Since the shell is very thin, the pull of the muscles used to open and close the shell, after a certain size is reached, seems to cause a median sinus to appear in the ventral valve, and a median fold on the dorsal front of the shell; later lateral radially arranged plications are formed on either side, theoretically symmetrical, though often not so in fact. Some species have minor radial plications in the median sulcus and on the median fold. The dorsal valve is higher than the ventral: the median fold and sulcus and other plications intertoothing to form distinctive zigzag patterns at the front of the shell. The hingle line is short, with low cardinal area. Beaks are incurved, the dorsal more than the ventral which is more pointed. Shell punctate. After apparant maturity is reached, the forward growth almost ceases and additions of shell material increase more rapidly the height of the shell, each addition making a distinct line of growth heightening the zigzag effect at the front. This is the herontic form.

The ventral valve bears in the interior three strong subparallel septa, the median straight, the lateral slightly diverging. The median rises low in front at the beak and rises high before reaching halfway to the front of the valve, where it is steeply truncated. The lateral septa are extensions of the strong dental lamellae which lie along the floor of the valve and decrease in height to almost halfway to the front of the valve. The greatly extended crural plates of the dorsal valve form two short diverging septa. Cardinal process is minute and linear; muscle scars very faint.

GENOTYPE: *Enteletes choristites,* Fischer de Waldheim.

Enteletes costadorsitriplicatus Bridwell. n. sp.

This species has the general *Enteletes hemiplicatus* and *pugnoides* characteristics, as to shape and surface markings, differing mainly in that the medial ventral sulcus contains two radial folds instead of none in *hemiplacatus* and one in *pugnoides.* The dorsal fold consists of the three minor folds in-

stead of one as in the *hemiplicatus* and two in *pugnoides*. Two specimens from the Captain Creek limestone having those characters, one southwest of Eudora, Kan., and one northwest of Garnett, Kan., have the following measurements:

Eudora specimen length, 15 mm.; width, 19 mm.; depth, 13 mm.
Garnett specimen length, 14 mm.; width, 17 mm.; depth, 12 mm.

The Eudora specimen is distored by oblique pressure, but not sufficiently so to produce the triplicate crenulations on the median fold, though a slight crack is produced at the point of the dorsal beak. This specimen was described in a paper read last year under the specific name *pugnax;* but since that name really begs the question on the hypothesis of origin, another specific name, *E. costadorsitriplicatus,* is used here.

Norman D. Newell, in the Journal of Paleontology (5:262, 1931), made the first attempt to reduce the genus to species. Heretofore all fossils of the genus were included under the one name, *Enteletes hemiplicatus.* I have tabulated the main measurements of the species as described and figured by Mr. Newell. At the bottom of the list the new species which I have described is added for comparison:

If we select hypothetically the two genera whose united characteristics might combine to form the new genus (whether true or not), it will help show how the variations which occur in a large assembly of specimens might arise. Let us select Meekella as one and Pugnax (which was later called Wellerella), as the other. Mr. Newell's pugnoides is so named because of its resemblance to Pugnax, whose ventral median sulcus is traversed by two radial ridges and whose matched dorsal fold has three ridges. *Enteletes pugnoides* has but one and two ridges, respectively. Both Meekella and Pugnax originated earlier than Enteletes; and both are usually found in the same rocks with Enteletes. The surface markings and course radial plications are more nearly like those of Meekella than any other Pennsylvanian fossil. If the ontogeny of the individual is the recapitulation of the phylogeny of the species, it hardly explains the appearance of the young shells; since Meekella apparently arose out of Schellweinella. But there can be no complete recapitulation of phylogeny where two lines of development have united; for it cannot develop in two ways at the same time. The characteristic most likely to persist being the one of longest standing. Here is where new life histories come into being, unlike either of the ancestral lines.

Suffice to say that there are no hard and fast fixed species—these all merge into one another and signs of the parent stocks crop out in various ways. Mr. Newell's pugnoides has half pugnax shape and plications.

The new species herein described has all the typical Enteletes surface markings, *i.e.,* lirae, sulcus and fold, but traversed by radial ridges exactly as in pugnax (*Wellerella osagensis*), save that here the resemblance ends and the lateral plications are like the typical *E. hemiplicatus.*

In 1932, Dunbar and Condra accepted Mr. Newell's species, *pugnoides,* and *hemiplicatus* var. *plattsburgensis,* but holds that *plattsmouthensis* is theærontic form of *hemiplicatus.* Certainly Mr. Newell's *hemiplicatus,* as illustrated, could not be so restricted, but there is yet to be studied much material which may yet show that *plattsmouthensis* is a legitimate species. Almost all of Mr. Newell's illustrations reproduced by Dunbar and Condra are speci-

GENUS *ENTELETES*

Species.	Measurements in mm. L. W. D.	Distance to plications mm.	Width of hinge line mm.	Ratio between M. Septa and shell length.	Horizon found.
E. plattsmouthensis Newell	26:29:25 30:31:30	10-12	12	1:2.2	Plattsmouth limestone.
E. pugnoides Newell	16:19:15	8mm. behind middle	8	1:2.4	Stanton limestone and below.
E. hemiplicatus restricted by Newell	16:18:12 16:19:14	Not given	5.5	1:2.3	Plattsmouth.
E. hemiplicatus var. plattsburgensis Newell	15:18:14	⅓ distance from umbone	9	....	Plattsburg limestone and below.
E. transversus Newell	18:23:16	½ distance from umbone	9	1:1.8	Lecompton limestone.
E. costadorsitriplicatus Bridwell	15:19:13 14:18:12	8 8	9	Not known	Captain Creek member of Stanton limestone.

mens showing no gerontic growth, whatsoever, while some are clearly immature.

Mr. Newell restricted certain species to definite horizons, agreed to by Dunbar and Condra.

My collections, however, will not bear out either Mr. Newell's restrictions nor those of Dunbar and Condra.

E. pugnoides and *E. hemiplicatus* var. *plattsburgensis* are used as markers for the Stanton and below, while *E. hemiplicatus* is limited as first appearing in the Plattsmouth limestone. I have one fine specimen from Captain Creek limestone from Eudora, Kan., which fulfills Hall's original description and measurements of *hemiplicatus* almost perfectly. So all three have been found outside Mr. Newell's limits as approved by Dunbar and Condra. If they are correct, however, the other alternative is that these apparently successively appearing formations are in reality the successive edges of parallel faults in the same stratum.

I have found from among three hundred specimens, seven of Enteletes with pugnoides characteristics, *i.e.,* plications traversing fold and sinus, in the Plattsmouth member of the Oread limestone, more than one hundred feet above the Stanton. The Oread limestone in western Douglas county is so similar to the Captain Creek that a driller seeking oil might stop a hundred feet short of his goal were he gauging his arrival at the Lower Stanton by fragments of either the species *pugnoides* or *hemiplicatus* variety *plattsburgensis,* for both of these apparently extend to the Plattsmouth member of the Oread. Or take hold of the other horn of the dilemma; if it is decided that these specimens are not identical, but closely related species, instead of one, there will be at least three new species to record.

Dunbar and Condra do not concede that Newell's varieties, *plattsmouthensis* or *transversus* are valid. My collections, however, show a number of specimens which are excluded by definition and measurements from their present species. Which shall we change, definition to suit specimens or continuously erect new species? As to size, we can tell where to put the big bear and the little bear, but what of those between?

Measurements alone are not specific characters. They may mean less food, less age, less favorable environment. Variation in measurements of comparative parts one to another, when there is no evidence of distortion, however, does make plain differences untrained eyes cannot see. Progressive variations in rapidity of growth may entirely change the shape of a shell so that the whole Enteletes group, starting something like a thin convex lens becomes more and more globose as maturity adds layer after layer of shell material on the inside only, in expanding concentric layers, until full maturity; after which new layers are still produced, adding little if any length or breadth to the shell; while the thickness or depth continues to increase. It seems to me that when two brachiopod shells, no matter what their difference in age may be, when closely associated should be considered to belonging to the same species, if the parts which are comparable are practically identical.

To what extent should practical usage stand in the road of changing many of our purely artificial classifications to that based upon the natural development? Certainly this cannot be done before segregated bits of knowledge are gathered together, compared and tested. Then the cold, bare facts of science must flash like a scimitar regardless of whose pet theory or classification may drop into the basket.

EXPLANATION OF PLATE

(Illustrations natural size)

Row 1. Enteletes costadorsitriplicatus Bridwell N. Sp. Dorsal, ventral, side and front views showing the triplicate nature of the median dorsal fold and the two folds in the sulcus of the ventral valve. Captain Creek Limestone, Eudora, Kan.

Row 2. Enteletes pugnoides Newell. Dorsal, ventral, side and front views showing the biplicate median dorsal fold and the single fold in the sulcus of the ventral valve. Plattsmouth Limestone, Marion Twp., Douglas county, Kansas.

Row 3. Enteletes hemiplicatus var. plattsburgensis Newell. Dorsal, ventral, side, and front views, showing the single median dorsal fold and single broad median ventral sulcus, being much smaller than the species. Plattsmouth limestone, Oread. S24, Twp. 4S, R 17E, Douglas county, Kansas.

Row 4. Enteletes hemiplicatus Hall. Dorsal, ventral, side and front views, showing much larger size and coarser markings. Plattsmouth limestone, Oread. formation, Douglas county, Kansas. (Should read hemiplicatus on the plate.)

Row 5. Wellerella osagensis (Pugnax formerly), Swallow. Showing the small shell, having a triplicate dorsal fold and biplicate ventral sinus, with two or three lateral folds, and small cardinal area. Pawhuska Limestone, Pawnee, Oklahoma.

Row 6. Meekella striatocostata Cox. Showing the large radial plications and finer striations so similar to the surface markings of Enteletes, but differing in high ventral beak and cardinal area. The front edges of the shell have no definite pattern as in Enteletes and (Pugnax) Wellerella. Plattsmouth limestone. Douglas county, Kansas.

Enteletes costadorsitriplicatus, Bridwell, N.Sp.

Enteletes pugnoides, Newell

Enteletes hemiplicatus v. plattsburgensis, Newell

Enteletes hemiplicatus, Hall

Pugnax (Wellerella) osagensis, Swallow

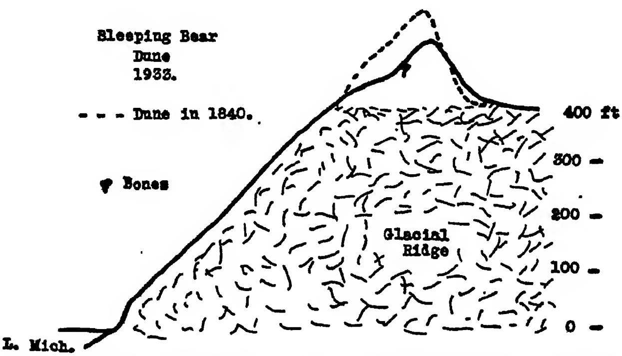
Mekella striatocostata, Cox

A Deposit of Mammal Bones Under Sleeping Bear Dune

DAVID M. GATES, Manhattan, Kan.

It was with a great deal of surprise that I found mammal bones in the eroding side of Sleeping Bear Dune in July, 1933. Bones usually decay quickly in sand deposits. Although these bones had been buried for perhaps a thousand years they seemed to be preserved unusually well.

The geological history of Sleeping Bear Dune dates back to the late Wisconsin Glacial period. The dune is situated on the east coast of Lake Michigan about thirty miles northwest of Traverse City, Mich. It is perched on top of a high plateau laid down by glaciers. The plateau is 400 feet above Lake Michigan and the top of the dune was once 125 feet above the plateau (figure). According to early white explorers the dune was still at this height through



Diagrammatic cross-section of dune, showing location of bones.

the nineteenth century. The dune was wholly forested when first seen by white man and probably had been for several hundred years. Due to trails made by recent white man the wind on the lake side was given a chance to gradually erode the dune and undermine the vegetation, thus exposing the crest to disintegration. The lake side of the dune and the crest, becoming exposed, rapidly blew away. For the last few years this has been taking place at the rate of about three feet a year, until now the top is only about ninety feet above the plateau. The inland side still remains densely covered with vegetation.

Besides a rather interesting geological history the dune also revealed a zoölogical history of noteworthy interest. In 1933, while with the plant ecology class from the Biological Station of the University of Michigan, under the direction of Dr. Frank C. Gates, I found the teeth of an elk (*Cervus canadensis*). About thirty-five feet of sand had been blown away from above the limey, crusty layer immediately under which the teeth were buried, on the lake side of the dune, the side which is now so rapidly blowing away.

The known facts of growth and erosion might suggest that the death of the elk took place about 1,000 years ago. The figure shows a cross section view of the dune and the location of the bones. Elk has formerly occurred over most of the state, but disappeared from the southern peninsula of Michigan after white man began their slaughter. It has now been reintroduced only in the Pigeon river region east of Wolverine. Other searches on the lake side of the dune have revealed fox, snowshoe rabbit, woodchuck, and martin bones. All of these were found about sixty feet below the present crest. The most interesting find of all was the right mandible of a martin (*Martes americana*). It was formerly known to occur in the region, but this is the first specimen from the district. The fox, snowshoe rabbit, and woodchuck, along with wild-cat and many rodents, are today quite prevalent in the region. Along with these bones I found an excellent clay Indian bead.

The Indians used the dune as a landmark from the lake, and an interesting legend surrounds its history as told by the Indians of the region. A mother bear and her two cubs were swimming to Michigan from the Wisconsin side of the lake where they had been suffering from famine. The two cubs drowned and are now the two Manitou Islands two miles off shore. The mother climbed upon the beach and fell asleep. As the legend goes she is still sleeping, the Sleeping Bear Dune. But it really seems as though the dune should have been named Sleeping Elk instead of Sleeping Bear. But perhaps the legend will have to take precedence over science as far as the name is concerned.

Shallow Aquifers in Eastern Kansas

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In many parts of the eastern third of Kansas the problem of securing sufficient water for domestic and farm use has become rather acute with the passing of the several recent dry seasons.

During stratigraphic studies some observations concerning the water-bearing characters of the rock layers have been made. Detailed work has revealed the presence of several areas of sandy shales and of lenticular or "shoe-string" sandstone bodies which carry a great deal more available water than is present in surrounding areas. Data concerning the thicknesses of the more persistent sandstones in the shallow subsurface have been collected. On many farms in areas of sandstone aquifers, ten or fifteen feet added to depths of wells would reach a nearly inexhaustible supply of water, as shown by the numerous very poor shallow wells in the upper parts of sandstones which in the same areas are supplying small municipalities or unfailing farm wells. Only a few of the limestones carry comparatively large supplies of water even though they lie below extensive and undissected dip slopes. Certain ones, however, are sufficiently porous to be important aquifers. The Winterset limestone, in western Linn county, and the Barneston limestone formation in the Flint Hills region furnish large supplies of water in drilled wells of small diameter.

The alluvial fillings along most of the smaller streams and along some of the larger ones consist largely of closely packed clay which is so impervious that the deposits are not aquifers. This is contrary to a rather prevalent idea that everywhere in the fillings of the valleys of permanent streams there is available water. Something of the character of valley fillings may be had from surface observations. The materials below slight depressions on the river flood plain which indicate old lakes are commonly underlain by fine materials which are not pervious enough to yield much water. This condition has been especially noticed in Marais des Cygnes valley. The character of the alluvial filling of Kansas River valley is rather well known. At Manhattan it is about seventy feet thick and at Kansas City is about eighty-five or ninety feet thick. In general it consists almost entirely of sand, ranging in size from fine to medium, with some coarse sand and gravel near the base. This deposit contains a vast supply of water and a great deal is being recovered for municipal, industrial and farm use.

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Relationships of Certain Recognized Lines of Weakness in Kansas to the Giant Zones of Epeirogenic Activity, the Megashears

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Confusion and serious errors have resulted at various times because of applying the word "shear" to rocks only where actual rupture has occurred under shearing stresses. As a matter of fact, it has often been proven that sheared rocks are weakened rocks, even though definite break did not result. It is evident that a word is needed which may be broadly applied where any kind or degree of deformation has been caused by shearing stresses. The word "megashear" may be applied in this way. Megashearing is defined as "Crustal deformation of any kind or degree which has been caused by multiple shearing stresses." Megashear is defined as "A more or less continuous line or zone of deformation of crustal rock caused by megashearing process.

Five groups or systems of megashears have been worked out in part and mapped.[1] The members of four of these systems are approximately rectilinear, while those of the other are arcuate. The system of nomenclature set up permits expansion as needed.

To students of epeirogenic matters it becomes apparent that not a week passes without sensible evidence of epeirogenic movements being left in the surface rocks in some part of the United States. These evidences indicate differential crustal movements which are so very slow as to be momentarily imperceptible, but whose cumulative effects over a considerable space of time constitute factors which must be taken into consideration. This is particularly true for mining, tunneling, and enterprises involving imposition of unusual weight upon certain zones. The lines or zones of megashearing mark the edges of crustal blocks of many kinds and sizes. The differential movements of crustal blocks due to accumulation of stress, are particularly apt to cause disasters in enterprises introducing new stresses, even though very small. It is along the borders of the crustal blocks, *i. e.*, in zones of megashearing, that differential movements of the crustal blocks most definitely show their effects and most distinctly leave their imprint, even though the igneous crustal rocks be deeply covered by sedimentaries. Also it is along such lines or zones that the physiographer finds the more unusual accentuations of the various processes of weathering and erosion.

Several years of travel over many parts of North America have enabled the writer to gather data upon many of these zones of megashearing, particularly in critical areas where zones of different systems intersect. In gathering these data. particular attention was paid to indications of vulcanism. The first tracing of zones of megashearing was done by using only such data; but soon it became apparent that other morphological elements, including many seemingly isolated and seemingly unrelated structures and surface forms, really are related. Personal examination of physiographic units was followed by a study of the

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1. Map not included.

geologic literature of that area. In the light of the principles of mechanics, and of studies by Hartmann, Bucher, Hoskins, Bailey Willis, T. C. and R. T. Chamberlin, Du Toit and others, it is not possible correctly to interpret such elements as being separate and entirely unrelated. Furthermore, as was briefly indicated by T. C. Chamberlin, the incontrovertible fact of the presence of stupendous diastrophic stresses, agreeing with mathematical calculations strongly indicate genetic mega-relationships between various groups of diverse structures.

It seems, therefore, that structures in line, even though of diverse nature, may be genetically related units of those greater structures, the megashears. Consequently, in the same megazone of crustal weakness, a long granite ridge was formed by the strong positive forces which were active in one space of geologic time; while in another segment in a different period, under different crustal conditions, a long zone of negative movement of the crust took place.

SOME LINES OF WEAKNESS IN KANSAS

The Nemaha Mountains, or the Buried Granite Ridge, have a trend nearly north-south, and underlie parts of the Flint Hills almost entirely across the state. Northward from the Kansas-Nebraska line they continue beneath the mantle rocks for an unknown distance, probably to end in what some have defined as an area of igneous uplift near the southwest corner of Minnesota. From that point this zone continues in about the same general trend, not as one of uplift, but as one of gentle negative movement, shaping the course of the Red River of the North, and the southern portion of Lake Winnipeg. Data are not available for the region farther north. From the Kansas-Nebraska line where the ridge is covered with less than five hundred feet of sedimentaries the trend is south, approximately fourteen degrees west. At El Dorado, Kan., the ridge is covered with something like eighteen hundred feet of sediments, which become thicker to the southward. In central Oklahoma it is lost, to reappear south of the Oklahoma-Texas line as a broad and gentle uplift known as the Bend Arch, whose trend continues in approximately the same direction to end in the Central Texas Mineral Region, or the Llano Uplift, northwest of Austin. This is an area of extreme orogenic uplift, vulcanism and mineralization. Farther to the south this zone of crustal disturbance is marked on the surface by a long line of deposits of opaline materials probably left by ancient hot springs which were able to rise through the crust because of its broken condition, which also is indicated by numerous faults that were discovered in drilling. Some small, but paying, oil-fields have been found on this structure. South of the Rio Grande this same trend is marked by a long line or zone of igneous stocks and plugs, whose intrusion, according to Ing. Gonzolo Vivar, was responsible for large accumulations of petroleum in the Mexican states Nueva Leon and Tamaulipas. Continuing south, in the same trend, a line of ancient volcanic craters extends to Hidalgo. From there evidence of active vulcanism leads, continuing south, to one of the world's most active areas of vulcanism, with almost continual seismic disturbances, where this great megashear intersects with two other systems in the region south and east of City of Mexico. Thus it will be realized that the Buried Granite Ridge is a part of one of the world's longest zones of crustal mobility. On the map of the Megashears, this structure appears as A—11.

Megashear B—7.

From the vicinity of the high divide near Palmer Lake, north of Colorado Springs, Colo., a broad zone of very gentle uplift extends far to the east. Along its axis, in Kansas, an active drilling campaign is now under way. From Salina eastward, the evidences of positive movement disappear and the trend is continued by a zone of gentle downward bending. This shapes the Kansas river to Kansas City, where the same structure creates an abrupt change in the course of the Missouri river for many miles, after which the river resumes a southeastward course. This tentatively is listed as Megashear B—7.

The Chautauqua Arch

This structure is believed to be separable as two structures which intersect in northern Chautauqua county. A line drawn along the axis of the southern arm, prolonged to the southeast, shapes the course of the Red River from Shreveport to the Gulf, and passes over the buried volcanic area of Llanoria. Prolonged to the northwest, this axis transects the great oil field near El Dorado, Kan., as well as that area of crustal activity in Kansas, the Salina Basin. It then exerts some influence on certain minor structures in the north central portion of Kansas. In Nebraska and South Dakota it becomes the principle axis of the Black Hills uplift, intersects a north-south megashear at Devil's Tower, Wyo., and extends on to unknown distance in Canada. This structure is mapped as Megashear D—14.

The Axis of the Kansas Permian Sea

This immense structure is in strong contrast with the Buried Granite Ridge. With the exception of three small igneous intrusions in Riley county, Kansas, this structure, so far as known at present, crosses Kansas as one of pronounced negative movement exclusively. But far to the southwest it transects several areas of ancient pronounced vulcanism, several areas of mineralization and present hot springs, to end at Las Tres Virgines, an area of vulcanism in Lower California, where one of the greatest seismic disturbances of the year was recently reported. Northeastward, from Kansas, this structure produces faulting in southwest Iowa, promotes mineralization in the area of giant jointing near Dubuque, shapes Lake Winnebago and Green Bay in Wisconsin and the buried canyon in the Straits of Mackinac, to end in the Canadian Shield, after assisting in promoting the strong mineralization of the Sudbury district. This structure is Megashear C—15.

CONCLUSIONS

While this state has not been subjected to orogenic activity in many geologic ages, it is transected by at least three and possibly four zones of epeirogenic activity. These divide the underlying crustal complex into not less than eight giant crustal blocks. By the writer's interpretation of the evidence, two of these blocks are in a state of delicately balanced equilibrium, which in due time probably will be adjusted by minor seismic activity. Careful checking of available evidence by geophysical surveys along megashears is recommended as a means of preventing further expensive disasters, as in constructing heavy dams, and particularly as a means of determining more fully the extent of our mineral resources.

Preliminary Report on Insoluble Residues of the Missouri Series, in Eastern Kansas

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This report follows an earlier study of the insoluble residues of Kansas Pennsylvanian rocks.[1] The residues included in that study were obtained from seventeen limestones which are exposed in Douglas county, Kansas. These limestones are members of formations included between the Stanton formation of the Lansing group, Missouri series, and the Hartford limestone member of the Topeka formation of the Shawnee group, Virgil series. This stratigraphic relationship is shown in figure 1.

The primary purpose of the preliminary investigation was to determine whether or not the various limestones could be differentiated on the basis of their insoluble residues. The results of that study indicated that the insoluble residues are diagnostic not only of the formations, but also of the members within the formations. It then seemed desirable to extend the study to include limestones of older formations of the Pennsylvanian system.

Acknowledgments. Thanks are due the Kansas Academy of Science for the gift of the Albert B. Reagan Research Award in 1937. This money was used to cover part of the expenses of field work and photographing. The writer also wishes to thank Prof. J. M. Jewett, of the Geology Department, University of Kansas, for assistance in the collection of outcrop samples.

In the present work samples were used from both outcrops and well cuttings. The counties in which one or more sets of samples were obtained are shown in the accompanying index map (fig. 2). Well samples only were obtained in Riley, Pottawatomie, Jackson, Lyon, Osage, Leavenworth and Coffey counties. Outcrop samples only were obtained in Franklin, Bourbon, Montgomery, Labette and Linn counties. Both well cuttings and outcrop samples were available in Douglas, Johnson, Wyandotte and Miami counties.

The main subdivisions of the Missouri series, named in descending order are, Pedee group, Lansing group, Kansas City group, Bronson group and Bourbon formation.[2] The stratigraphic relationship of these major divisions is shown in figure 1. Altogether, twenty-one limestone units are included within the Missouri series.

DESCRIPTION OF RESIDUES

All of the residues studied contain chert and silicified organic remains except those from the Little Kaw member of the Stanton, which is the uppermost formation of the Lansing group, and those from the Hertha limestone, the lowest formation of the Bronson group. The residues from these beds are predominantly sand.

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Schoewe, W. H., Keroher, Grace C., and Keroher, R. P., Preliminary Study of Insoluble Residues of Kansas Pennsylvanian Rocks. Trans. Kan. Acad. Sci., 40:269-281. 1937.

2. Moore, R. C., Stratigraphic Classification of the Pennsylvanian Rocks of Kansas. Bull. State Geol. Survey of Kansas No. 22, 1935.

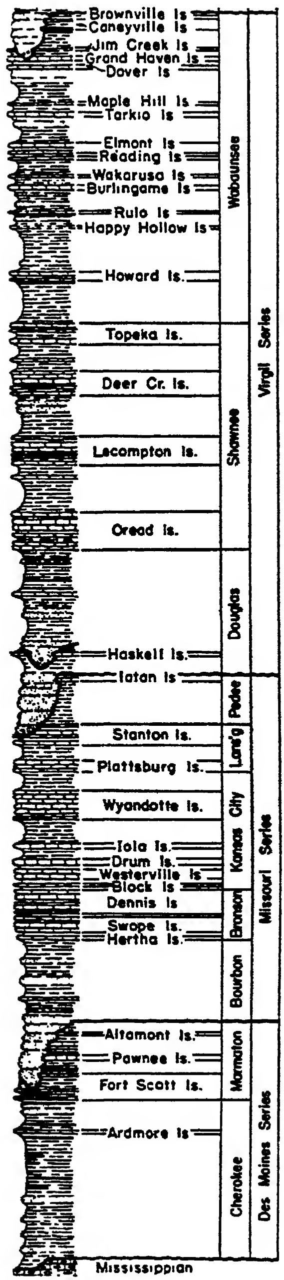


FIG. 1. Geologic column, showing stratigraphic relationship of limestones studied.

There is considerable variation in the appearance of the chert. There are noticeable differences in color, luster, texture, and degree of opacity. The color varies from pure white through gray-white, dark gray, various shades of tan to a dark blue-black. Some of the chert fragments are smooth and shiny, while others are dull. Some have a waxy luster resembling paraffin. Several variations in texture are noticeable. Some pieces of chert are smooth while others are rough or in some cases granular. Gray and white porous chert is common in many residues. The pores appear to have been formed by the dissolving of fossils or oölites by the acid. The chert varies from opaque to translucent. Apparently no dolocastic chert is present.

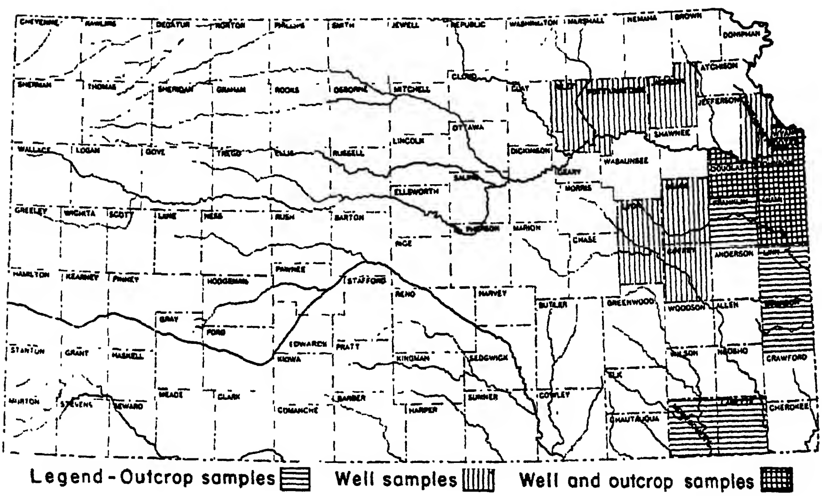


FIG. 2. Index map showing location of counties studied.

The chert alone is, in most cases, presistent enough and of such a character that it may be used to distinguish the various members. The organic material is not sufficiently persistent to permit recognition of the beds on paleontological evidence alone, but appears to have some value when its association with different types of chert is considered.

Pedee Group

The Pedee group contains only one limestone formation, the Iatan. No outcrop samples were obtained from this member and its recognition in the well cuttings was doubtful; therefore it is omitted from further consideration in this study.

Lansing Group

The Lansing group contains two limestone formations, the Stanton and the Plattsburg.

Stanton formation. The Stanton formation consists of five members, three of which are limestones. They are, in descending order, Little Kaw, Stoner and Captain Creek limestones.

Quartz grains compose approximately three-fourths of the residue from the Little Kaw member. They vary in size; many are very small and sharply angular, but the larger ones are angular to subangular or even fairly well rounded. Many of the latter are frosted. The remainder of the residue consists of gray, sandy shale, gray porous chert, and mica flakes. The mica flakes are very large, many of them measuring as much as 0.6 mm. (Pl. I, fig. A.)

Fragments of gray sandy shale constitute the greater volume of all residues from the Stoner limestone member. The chert occurring in this member is white and of three varieties—a smooth type, a porous chert, and a rough, slightly granular chert. Small white oölites and organic remains compose a small percentage of the residue. (Pl. I, fig. B.)

The residues from the Captain Creek thus far have yielded gray micaceous shale, sandy shale, organic remains, and pyrite, none of which may be considered diagnostic. Further study will be made on this member as better samples become available.

Plattsburg formation. The Plattsburg formation contains the Spring Hill and the Merriam limestones.

The characteristic residues from the Spring Hill member contain a tan, fossiliferous, mottled chert, some fragments of which are smooth and dull, while others have a waxy luster. The waxy chert is somewhat darker in color than the smooth, dull chert. Gray-white porous chert and white rough chert are also present. The organic remains present consist mainly of brachiopod spines, encrusting foraminifera, crinoid fragments, and in some samples ostracodes, fragments of fusulinids and mollusk shells. (Pl. I, fig. C.)

Gray waxy chert distinguishes the Merriam member from the Spring Hill. Some fragments of this chert are opaque and others are translucent. Both types may be fossiliferous. The residues also contain gray-white porous chert, white rough chert and organic remains similar to those found in the Spring Hill member. (Pl. I, fig. D.)

Kansas City Group

The Kansas City group contains five limestone formations. They are, in descending order, the Wyandotte, Iola, Drum, Westerville and Block limestones.

Wyandotte formation. No attempt has been made as yet to differentiate the three members of the Wyandotte formation. One noticeable feature is the small residue yielded by the limestones; this in itself may be diagnostic of the formation. All of the residues contain chert and silicified organic remains. The chert varies in color from white to light gray and tan. Thus far no dark-colored chert has been noticed.

Iola, Drum, Westerville, Block formations. Study of these formations is incomplete, due to lack of sufficient outcrop samples. Because of relatively large variations in thickness, together with disappearance of some of the beds locally, not all of these formations are easily recognizable from well cuttings. Therefore a report is withheld pending the accumulation of a greater number of samples.

The presence of considerable chert in the residues from the samples available, together with abundant organic material, suggests that further work may reveal characteristic residues for at least some of these formations.

Bronson Group

The Bronson group contains five formations, three of which are limestones. They are, in descending order, Dennis, Swope and Hertha limestones.

Dennis formation. The Dennis formation contains two limestone members, the Winterest and Canville.

The characteristic residue from the Winterset is a black or a dark blue-black chert. This chert shows many variations from well to well and even within the same sample. Some of the fragments are all black, opaque and very shiny; other types are likewise black, but have a definite waxy luster, while still other fragments are translucent. This chert may be dotted or banded with white or have a mottled appearance. In some cases the markings producing the dotting, banding, or mottling consist of white chert which resembles paraffin. The more translucent pieces appear to be a shade of blue-black rather than pure black. This blue-black tinge serves to distinquish these fragments from the gray, waxy, somewhat less translucent chert of the Plattsburg. Much of the chert is oölitic or fossiliferous.

The Winterset residue also contains white chert which varies in texture. The textural range includes dense, smooth chert, dense rough chert and porous chert. A large amount of light tan chert, some of which is fossiliferous, is present. The organic material contains fragments of bryzoans, crinoids, fusulinids, brachiopod spines and molluscan shells.

The black chert in this member is the most distinctive marker yet found in the Missouri series. It occurs in all but four of the wells studied. Its absence in these cases is believed to be due to faulty sampling. Further study may prove this chert to be a usable marker in the so-called "Lansing-Kansas City" beds of central and western Kansas. (Pl. II, fig. A.)

A large amount of white porous chert is present in the outcrop samples of the Canville. As yet it has not been possible to trace this member from well to well, perhaps because white porous chert is quite common in the overlying limestones, and also because it may not be well represented in well cuttings due to the thinness of the member.

Swope formation. The Swope formation contains two limestone members, the Bethany Falls and Middle Creek. Of these only the Bethany Falls has been studied.

The typical residue from the Bethany Falls is a nearly white, opaque chert, with a dull luster. Most of the fragments are fossiliferous. Many of them contain fusulinids, complete shells of minute brachiopods, and broken shells of larger ones. This chert is accompanied by a coarsely granular (sugary) oölitc, chert. Large quantities of white porous chert and minor amounts of a white waxy chert are commonly present. (Pl. II, fig. B.)

Hertha formation. The residue from this formation is dominantly a very fine white sand. The quartz grains are very clear and sharply angular. The extreme fineness of the sand distinguishes it from the sand of the Little Kaw limestone member of the Stanton formation. Some samples contain minor amounts of fine organic material and pieces of white smooth chert and porous chert. (Pl. II, fig. C.)

Particular attention was given to the sandy residue from the Hertha, in an attempt to subdivide this formation. According to Jewett[3] field evidence in-

3. J. M. Jewett. Personal Communication.

dicates the existence of more than one member in the Hertha. The residues, however, appear very similar throughout the entire Hertha zone. The only variation is a possible difference in the size of the sand grains.

CHART SUMMARIZING RESIDUES STUDIED

Group.	Formation.	Member.	Characteristic residues.
Pedee	Iatan		Not studied.
Lansing	Stanton	Little Kaw	Coarse sand; gray sandy shale; large mica flakes.
		Stoner	White smooth chert; white porous chert; oölites; gray sandy shale; organic material.
		Captain Creek	
	Plattsburg	Spring Hill	Tan, fossiliferous, mottled chert; organic material.
		Merriam	Gray, waxy, mottled chert; organic material.
Kansas City	Wyandotte	Farley Argentine Frisbie	Members not studied in detail. Residues characteristically small. All residues contain chert and organic material. Chert, white and tan. No dark chert noted.
	Iola	Raytown	Not studied in detail. All residues contain chert and organic material. No dark chert noted.
		Paola	
	Drum	Corbin City	
		Cement City	
	Westerville		
	Block		
Bronson	Dennis	Winterset	Black and dark blue-gray-black chert that is mottled, banded, fossiliferous, opaque to translucent. Light tan chert; white porous chert. Organic material.
		Canville	
	Swope	Bethany Falls	White to gray-white, mottled, fossiliferous chert; granular oölitec chert; large granular oölites; white porous chert; organic material.
		Middle Creek	
	Hertha	Sniabar	Fine white angular sand. Organic material.
		Critzer	

PLATE I

A. Little Kaw limestone. $\times 7$.
B. Stoner limestone. $\times 7$.
C. Spring Hill limestone. $\times 3\frac{1}{2}$.
D. Merriam limestone. $\times 3\frac{1}{2}$.

PLATE I

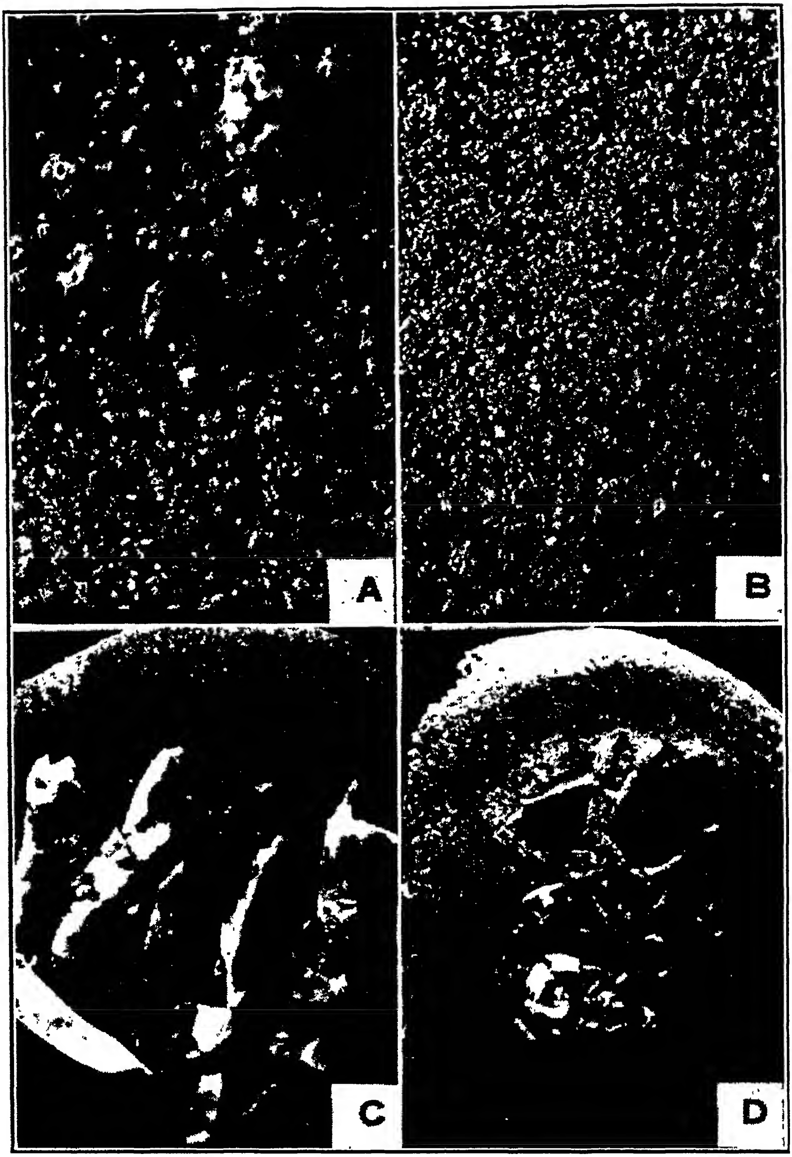
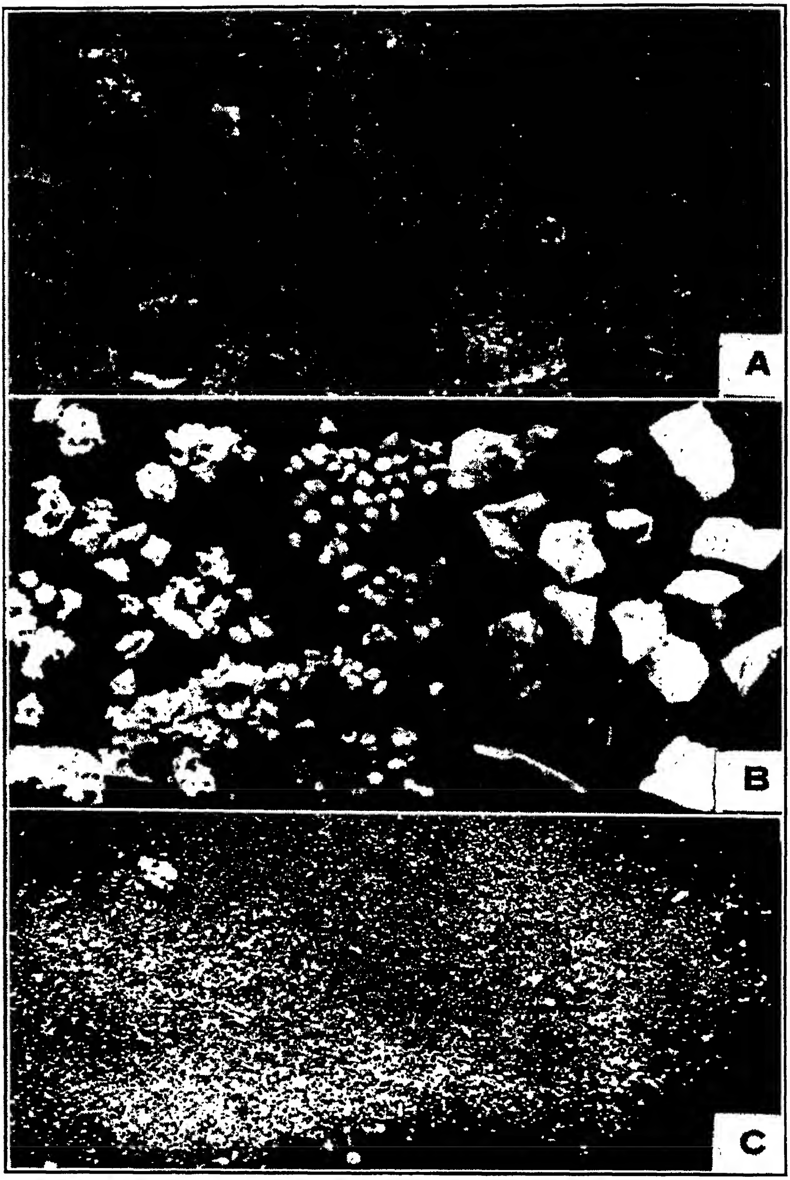


PLATE II

A. Winterset limestone. $\times 3\frac{1}{2}$.
B. Bethany Falls limestone. $\times 3\frac{1}{2}$.
C. Hertha limestone. $\times 3\frac{1}{2}$.

PLATE II



An Upper Silurian Vertebrate Horizon, with Description of a New Species, *Cephalaspis oeselensis*

GEORGE M. ROBERTSON, F. H. K. S. C., Hays, Kan.

The earliest vertebrate fossils of which we have knowledge are fragments from the Upper Ordovician, the best known being from the Harding sandstone near Canon City, Colo.

The next horizon at which vertebrate fossils have been recovered is Upper Silurian. If the stratigraphy has been correctly deciphered, the deposits in the dolomitic limestones of the Estonian island of Oesel, in the Baltic, are of Middle Ludlow, and are the earliest of the Upper Silurian vertebrate remains.

In 1889 Dr. William Patten published a paper on the origin of Vertebrates from Arachnids (*1*). The hypothesis there put forth sought to link the most primitive vertebrates, the Ostracoderms, with the Merostomes. The most thorough account of that theory was published in book form in 1912 (*2*), but most of Doctor Patten's research, from 1900 until his death in 1932, was devoted, directly or indirectly, to that theoretical work.

In order to develop his theory more completely, it was necessary that he should have more material to dissect and study, and as Ostracoderms were not plentiful in museums and where present were not available for dissection, Doctor Patten made his own collection. His search for fossils took him to many regions, but his most successful collecting was in the island of Oesel. He made four trips to the island, the last two being especially successful. He returned from the last, and most successful, trip in September, 1932, and died a month later.

Through the kindness of his widow and his son, Dr. B. M. Patten, and of the administration of Dartmouth College, I was given the opportunity of studying the Patten collection at Dartmouth College, a work which has occupied my research time since the fall of 1932.

Ostracoderms have been known from Oesel since the middle of the last century, although most of the material was fragmentary. The first ambitious work on them was done by Pander in 1856 (*3*). In this paper were described 28 genera and 42 species, most of them based on minute fragments of bony shields or on isolated Coelolepid scales. The chief of the workers publishing on the Oesel vertebrates have been Schmidt and Rohon, between 1866 and 1900, and Patten between 1900 and 1932. My publications date from 1935 to the present.

A skeleton outline of Ostracoderm classification will serve as a basis for discussion of the Oesel horizon. Omitting lower categories and summarizing in places, such an outline follows:

- Class Ostracodermi (Cyclostomata)
  - Subclass Pteraspidomorphi
    - Order Thelodonti
      - Family Coelolepidae
    - Order Heterostraci
      - At least five families

Trans. Kansas Acad. Science, Vol. 42, 1939.

Order Palaeospondyloidea
Order Myxinoider (not known as fossil)
Subclass Cephalaspidomorphi
Order Anaspida
Six families
Order Osteostraci
Family Cephalaspidae
Fifteen genera
Family Tremataspidae
Family Dartmuthiidae
Two genera
Family Oeselaspidae
Order Petromyzontia (not known as fossil)

The only members of the Pteraspidomorphi known from Oesel are Coelolepidae. One species, *Coelolepis luhai* Kiaer (*4*), is well established. A number of genera and species founded by Pander on isolated scales await revision. The Patten collection has about 100 specimens.

Both orders of fossil Cephalaspidomorphi are known from Oesel. The Anaspida from that horizon, known only from the Patten collection, are fragmentary. They have not yet been described, although their occurrence has been recorded (*5*).

Of the Osteostraci, all four families are present, three of them being known only from Oesel. Of the Cephalaspidae, the genera *Cephalaspis, Thyestes, Witaaspis,* and *Saaremaaspis* have been recorded. Rohon (*6*) also described a specimen of *Eukeraspis,* but the description is inadequate and I have been unable to verify his identification. Pander (*3*) described *Cephalaspis schrenckii* from Oesel, but that generic identification was incorrect, and I have erected a new genus, *Witaaspis,* for it on the basis of specimens in the Patten collection and of specimens in the National Museum at Moscow (*7*). I have discovered another species of *Witaaspis* which I am designating as *Witaaspis patteni,* but the description is not published as yet. In the present paper I am describing the first actual member of the genus *Cephalaspis* from that horizon, *Cephalaspis oeselensis* n. sp. The genus *Saaremaaspis* was erected from material in the Patten collection and in the collections of the National Museum at Moscow (*8*). *Thyestes verrucosus* was described about the middle of the last century by Eichwald (*9*).

The family Tremataspidae is the best known Oesel family. It contains but the one genus, *Tremataspis,* with seven species and two others which are doubtful (*10*). The Patten collection contains over 2,000 specimens of that genus and six of the seven good species have been described from it. Dissection of such features as the brain case and sense organs has been possible with this genus.

The family Dartmuthiidae was designated by Patten the year before his death (*11*), but was not adequately described by him. It contains two genera, *Dartmuthia* and *Rotsiküllaspis* (*12, 8*), each with a single species.

The Oeselaspidae, with but one genus, *Oeselaspis,* and a single species, was also based on the Patten collection (*13*).

To sum up the material from this horizon, both subclasses of Ostracodermi

are represented, the older group, the Pteraspidomorphi, but meagerly. The two fossil orders of the Cephalaspidomorphi are both represented, and of one, the Osteostraci, more families are known than from any other horizon, only the Cephalaspidae being known from the Devonian. Two subclasses, three orders, six families, ten genera, and seventeen species, to count only those which can be certainly identified, is a remarkable record for the earliest horizon from which adequately preserved vertebrate fossils have been recovered.

The list which follows includes only those species which appear to be certainly valid:

Subclass Pteraspidomorphi
- Order Thelodonti
  - Family Coelolepidae
    - *Coelolepis luhai* Kiaer

Subclass Cephalaspidomorphi
- Order Anaspida
  - Present as fragments.
- Order Osteostraci
  - Family Cephalaspidae
    - *Cephalaspis oeselensis* n. sp.
    - *Thyestes verrucosus* Eichwald
    - *Saaremaaspis mickwitzi* (Rohon)
    - *Witaaspis schrenckii* (Pander)
    - *Witaaspis patteni* Robertson
  - Family Dartmuthiidae
    - *Dartmuthia gemmifera* Patten
    - *Rotsiküllaspis obrutchevi* Robertson
  - Family Oeselaspidae
    - *Oeselaspis pustulata* (Patten)
  - Family Tremataspidae
    - *Tremataspis schmidti* Rohon
    - *Trematąspis milleri* Patten
    - *Trematаspis mammillata* Patten
    - *Trematаspis rohoni* Robertson
    - *Trematаspis patteni* Robertson
    - *Trematаspis panderi* Robertson
    - *Trematаspis scalaris* Robertson

The new species to be described belongs to *Cephalaspis,* the type genus of a family of the Osteostraci. The Osteostraci all possess bony shields which enclose the head and generally something of the trunk. The naso-hypophysial aperture is unpaired, dorsally situated, anterior to the eyes. The orbits are high dorsally and approximated, with a pineal saddle between them. All Osteostraci so far known have peculiar depressed areas posterior to the orbital region and probably in all cases these areas were covered by bony elements, although these are seldom preserved. Similar depressed, bone-covered areas lie near either lateral margin on the dorsal surface. I refer to these areas as the dorsal and lateral fields. These fields are well supplied with nervous and vascular channels and have had a variety of functions ascribed to them.

The ventral side of the shield has anteriorly a large oralo-branchial chamber

within which are sometimes preserved impressions of gill tubes which appear to have been of Cyclostome type. This chamber was closed ventrally by a series of bony plates which are seldom preserved in the fossils. Posterior to the chamber there may be a solid portion of the shield or only bony scutes or scales covering the rest of the venter.

The trunk region posterior to the shield and the caudal region are known in detail in few specimens, but the traces of these regions in other specimens seem to conform to the same pattern. This region was encased in scutes or scales, a row of capping scutes dorsally, laterally two or three rows of dorso-ventrally elongated, narrow plates, somewhat like those of the Anaspida, and ventrally more irregularly arranged scales.

In the Cephalaspidae the shield covers the head and extends back a short distance onto the trunk. The shield may possess cornua, which are mere vestiges, but cornua are always present in the family. The lateral fields are undivided. The dorsal and ventral shields may be fused marginally, although in most cases the postbranchial region of the venter is so little preserved that one can not determine this characteristic. The postbranchial region of the shield is short. Plates over the chamber are known in but few cases, and where known are small and numerous.

Cephalaspis has a relatively short shield. The cornua are quite variable, but generally are at least as long as the trunk division of the shield. Pectoral sinuses within the cornua are well-defined. Traces of appendages are known in a few instances. The ventral shield posterior to the oralo-branchial chamber is relatively short, and in most cases is not preserved. How closely fused it may have been with the dorsal shield is thus not known in most instances. In some cases this fusion marginally seems to have been complete. The lateral fields are long, extending at least to the cornua in those species in which the fields are known. The dorsal field is relatively long, starting immediately behind the pineal region and extending posterior to the endolymphatic apertures, which in many cases at least seem to have opened within the field. The plates over the oralo-branchial chamber are known in very few cases. In these they are small, numerous, and apparently irregular in arrangement, contrasting with those of *Tremataspis*. Generally the orbits are located about half way between the rostral margin and the level of the pectoral sinuses. The naso-hypophysial fossa and aperture lie in part between the forward portions of the orbits.

Cephalaspis oeselensis n. sp. (Figures 1, 2)

The holotype of this species is specimen C 10 of the Patten collection. The number of specimens in this collection which appear to pertain unquestionably to this species is 21, though a considerable number of additional specimens probably pertain to it as well. Specimen 6487 of the Museum of Comparative Zoölogy at Harvard University also belongs to this species.

The length of the shield is approximately 23-29 mm., the width at the level of the pectoral sinuses about 30-37 mm., varying with the degree of flattening. The cornua are moderately long and broad, the distance from the rostral margin angle to the cornua tip being between 3.6 and 4.4 times the cornu length, the cornu length being 1.5 to 2.5 times its breadth at the base. The ornamentation of the cornua is of elongated tubercles, seeming to be massed

together toward the cornu tip. The distance from the rostral angle to the pectoral sinus level is about 1.6 to 2 times the distance from the rostral angle to the orbits. The orbits are of medium size, about 3 x 2-2.5 mm., and oval in form. Ossified sclerotics have not been found. The inter-orbital distance is about 2 mm. A trace of a pineal plate between the orbits is visible in one specimen (fig. 2). The naso-hypophysial fossa is wide and deep, the foramen long, set in a prominent ridge in the fossa. The dorsal field is narrow, lenticular, bordered by ridges. The lateral fields are long, from anterior to the nasal level back to the base of the cornua. Apparently six nerve trunks run to each lateral field, the two anterior trunks being within a common encasement until about half way between the orbit and the field. The ornamentation consists of bun-shaped and spinelike tubercles, the former being on the margin, the latter on the general surface. Each spine is set in the middle of a polygonal area about 1 mm. on each side. The margins of the pectoral sinuses are denticulate. The posterior portion of the dorsal shield shows traces of segmentation. Branchial tubes and a post-branchial wall similar to those found in other cephalaspids are found. The venter is incompletely known. The oralo-branchial chamber was large. None of the plates of this region have been found.

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EXPLANATION OF PLATE

Cephalaspis oeselensis, n. sp.

FIG. 1. Holotype. Specimen C 10, Patten collection, Darmouth College. Inner aspect of dorsal shield × 2.

FIG. 2. Specimen C 100, Patten collection, Dartmouth College. Impression and partly inner aspect of dorsal shield × 2. Something of the ornamentation, the dorsal field outline, the pineal plate impression, and traces of nerve channels to lateral fields.

Elephant Graveyard: A Preliminary Report

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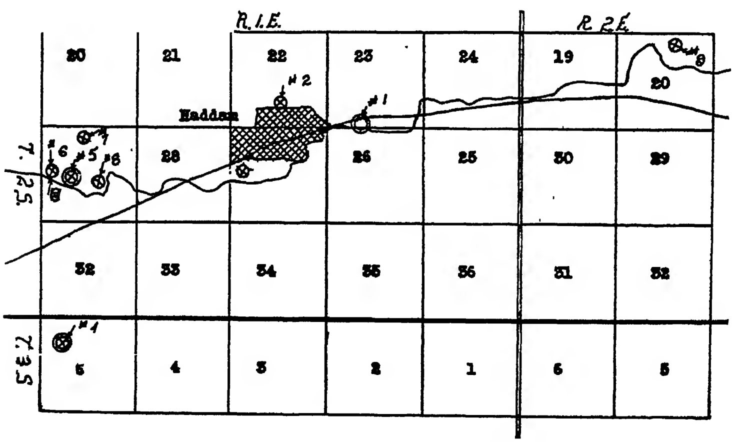
While the Kansan ice sheet reached its farthest southwestern advance, its front occupied a curve roughly outlined by Hanover, Manhattan and Topeka. Some of its effects may be noted in Washington county where Mill creek, with its source in eastern Republic county, flows east and northeast to its junction with the Little Blue near Hanover. During a portion of the Kansan glacial stage, the free flow of Mill creek was interrupted by the ice barrier or by the sheet wash fronting the ice, and a small lake was formed in the Mill creek valley. Along the north side of this valley extending for a number of miles, a terrace some twenty to thirty feet in height consisting of Kansan Pleistocene deposits contains the remains of elephants of several different species.

Evidence of this glacial elephant graveyard may be listed along a line seven miles in length, extending east and west from Haddam, Kan. Bones of elephants have been found at nine localities. Two of these are within 100 yards of each other and may be parts of the same skeleton. Five of the finds have been exposed by the natural process of erosion and four have been uncovered by grading or ditching operations. With one exception all the finds have been on the north side of the creek and on or near the inner slope of the terrace mentioned above. Three of the localities yield teeth or bones that are distinctive of three separate species. The accompanying map shows the location of the finds.



Map showing townships, town, railroad and site of graveyard.

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Location number 1 yielded a skull without tusks and a complete lower jaw with the teeth well preserved. This skull and jaw are classed as ***Elephas columbia.*** Parts of the teeth from location number 4 belong to the hairy mastodon, *Mastodon americanus.* Leg bones from location number 5 belong to the giant among elephants, *Archidiscodon imperator,* or to a species fully as large. The articular surface at the distal end of the humerus of this specimen measures 13 inches across and 7 inches from front to back.

Within a mile of location number 1 two other finds have been made. One of these was uncovered by workmen of the town of Haddam who were digging a ditch. The men in charge of the work noticed that a large bone at the bottom of the trench showed signs of crumbling; after excavating around it and consulting the town officials, the ditch was ordered filled to protect the specimen from further disintegration. I did not see this large "bone," but from descriptions given me it is doubtless a tusk. Unless the town officials undertake further excavation to secure these bones for a public exhibit, some institution may get permission to acquire them. Within half a mile of the place of discovery of the huge leg bones at location number 5, three other places have yielded elephant remains. Location number 9 is four miles east and north of Haddam in a road cut just north of Mill creek. At this place two femurs and other bones were found. The heads of the two femurs, along with some other bone fragments, make part of a border around a flower bed at a nearby farm. As no systematic search of Mill creek valley has been made, further exploration may yield additional skeletal material.

While bones and teeth of elephants are not rare in other parts of Kansas, they seem to be most abundant in the north central part of the state. Near Clifton, about 22 miles south of Haddam, several elephant and mastodon teeth have been secured from sandpits and numbers of similar teeth have been pumped from sandpits at Concordia, Clyde, and Clay Center. The abundance of proboscidian fossils in north central Kansas suggests a highly favorable environment for this group during Pleistocene time. The extreme concentration of skeletal parts in the region along Mill creek near Haddam probably indicates a set of unusual conditions favoring the burial, but conditions indifferent to the preservation of the fossils. Whatever conditions may have been, we can imagine great herds of these animals roaming over the plains of Kansas during the time of glaciation.

Whether these huge mammals broke through the ice of Mill creek and perished, leaving their bones along the edge of the terraces at the limit of the deep water, or whether they met less spectacular deaths, we will leave to the imagination. A more careful study of Mill creek valley and the northeast portion of Washington county may yield valuable information as to the limits of glaciation in this region and of the effects on the drainage of the land near the glacial front. Also, more Proboscidian remains may be found, as well as less spectacular members of the fauna of that remote time.

Evidences for the Relocation of West Drift Border in Eastern Kansas

W. H. SCHOEWE, University of Kansas, Lawrence, Kan.

Field investigations carried on in the region of the attenuated drift border in northeastern Kansas indicate that an ice sheet extended beyond the limits of the previously mapped west glacial border. (Fig. 1.) The evidences cited are the presence beyond the glacial border of: true till deposits, unusually abundant and widespread erratics both near and remote from the glacial border, and unsorted drift occupying places without any regard for topographic position or elevation. The new mapping which adds approximately 450 square miles to the ice-invaded area of Kansas also is in agreement with the newly established glacial drift border in Nebraska.

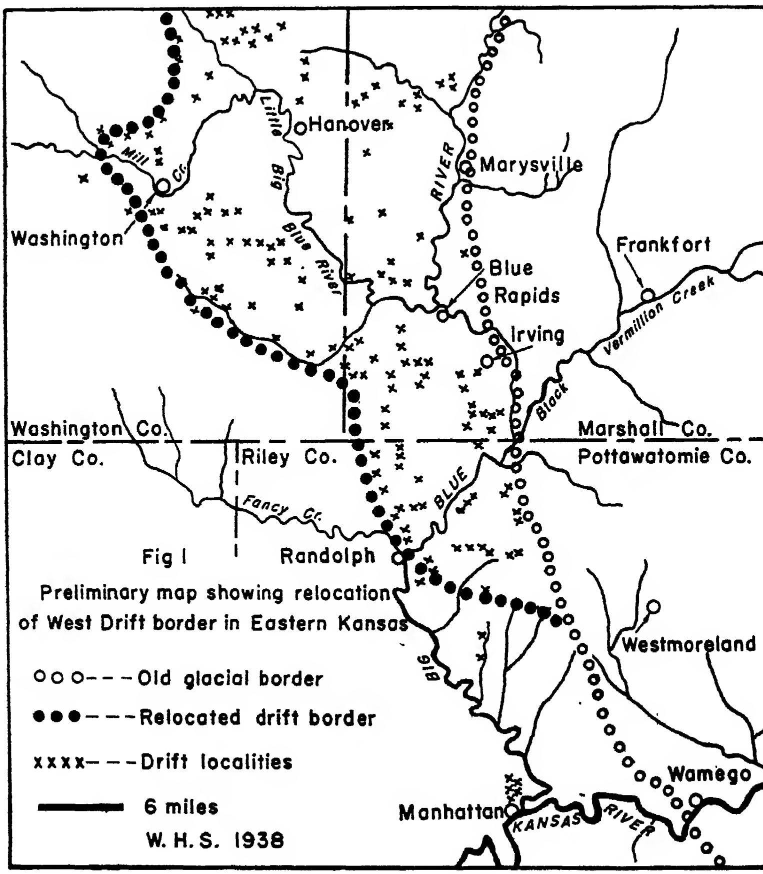

Fig I
Preliminary map showing relocation of West Drift border in Eastern Kansas

Recent Developments in Meteorological Research [1]

By CHARLES F. SARLE, Principal Agricultural Economist, Washington, D. C.

It has been suggested that many of those attending the Seminar would like to hear something about recent developments in meteorological research and their application to weather forecasting. No doubt some of you have been encountering new words and phrases in your reading relating to meteorology—new expressions such as radio meteorograph, isentropic charts, tongues of moist and dry air, cold fronts, warm fronts, hydrometeorology, and agrometeorology, all of which sound somewhat mysterious to the layman.

Perhaps the best way to obtain a picture of some of the recent developments in the science of meteorology and to learn how these new terms are used is to review briefly some of the research that has been carried on during the past two or three years by the Department in coöperation with Massachusetts Institute of Technology and Harvard University, and more recently with the University of Rochester, New York University, and California Institute of Technology.

This research in the field of meteorology has been carried on at the same time as the research in the field of what I like to call agrometeorology—or the study of how the meteorological environment influences plant growth and the yield per acre of important commercial crops such as wheat, corn, and cotton. The agrometeorological, or crop-weather, research is being carried on by the Department in coöperation with several of the leading state agricultural experiment stations, including Kansas, Iowa, Ohio, Tennessee, and South Carolina. I shall not attempt to discuss the agrometeorological research in any detail at the present time, but at the close of my paper I shall mention the results of a small study concerning the development of a practical method of forecasting the yield of wheat in the prairie provinces of Canada that has been completed recently by one of the men who are working directly with me in Washington.

LONG-RANGE FORECASTING

One of the first steps in the meteorological research was a critical analysis of existing theories and methods of long-range weather forecasting. This study was conducted along both physical and statistical lines. Those whose published work has been studied (naming leaders where several were associated) are: (1) G. F. McEwen, Scripps Institution of Oceanography, on correlations between sea surface temperatures and subsequent California rainfall, and periodicities in the latter; (2) Sir Gilbert Walker, Indian Meteorological Office, on world correlations, especially with the object of forecasting rainfall in India, and on the theory of large-scale oscillations; (3) G. P. Multanowski, U. S. S. R. Institute of Long-Range Forecasts, on paths of cyclonic storms as related to their origin, and on the influence of Arctic ice and other factors; (4) other investigations of the relation of polar ice to subsequent weather, including those of Wiese, Meinardus, Brennecke, Mossman, and C. E. P.

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1. Address, Kansas Weather-Crops Seminar, Wichita, Kan., October 28, 1938.

Brooks; (5) Dr. C. G. Abbot, Smithsonian Institution, variations in the solar constant and their relation to weather changes; (6) Helland-Hansen and Nanssen, on variations in ocean currents as a factor in long-range weather forecasting; (7) H. H. Clayton, on solar variations and periodicities; (8) Dr. Franz Baur, German State Research Institute for Long-Range Weather Forecasting, combined statistical and meteorological approach to seasonal and ten-day forecasting.

I am very sorry to have to report that these various systems of long-range weather forecasting have not stood the test of critical evaluation and verification except in the preliminary verification made by Mr. Larry F. Page, Mr. Irving I. Schell, and Mr. Philip F. Clapp of the Bureau of Agricultural Economics (the latter now of the Weather Bureau) of a four-year series of ten-day forecasts by Doctor Baur. These forecasts verified with a success somewhat better than pure guessing, but were much better for the first five-day period than for the remainder of the ten-days period. The degree of success obtained was found to be somewhat greater than could be expected by use of the well-known principle that certain types of meteorological conditions, once started, tend to persist in many cases for a considerable period of time.

Although no system was found that could be reliably applied to long-range forecasting beyond a period of five or ten days, the ground has been cleared for further studies that might lead to the development of new methods or at least that would produce new ideas and techniques applicable to forecasting. It is expected that the results of this reconnaissance survey of existing methods of long-range weather forecasting will be published in the near future.

In addition to the methods mentioned, several other systems were tested by means of comparing their forecasts with the actual conditions. Such methods as those of Selby Maxwell and Tippenhauer cannot be judged in any other way, since they are not based on any recognized scientific knowledge.

ANALYSIS OF THE NORTHERN HEMISPHERE CHARTS

Beginning in the fall of 1936, the careful analysis of a continuous series of Northern Hemisphere charts (once daily) has been carried on at the Massachusetts Institute of Technology under the direction of Dr. H. C. Willett of the Meteorological Division. The purpose of this synoptic or weather-map method of attacking the problem of long-range weather forecasting was (1) to discover in a general way how marked deviations from normal weather over a given region, weather anomalies as they are called, may be traced to the activities of the "centers of action" in the atmosphere; and (2) to look for possible empirical clues as to the future state of the general circulation in its current state and present tendencies.

Concerning the first of these two objectives, it has long been realized by weather forecasters that there is a close correlation between the circulation pattern and the local anomalies of the different meteorological elements. By the circulation pattern is meant the location and intensity of the so-called *centers of action*, or the semipermanent or persistent centers of high and low pressure of the Northern Hemisphere, with their corresponding systems of prevailing winds. The principal centers of action over the Northern Hemisphere during the winter season are the cold Siberian and North American high-pressure areas, the Icelandic and Aleutian low-pressure areas, and the subtropical high-pressure area over the Atlantic known as the Bermuda high,

and the corresponding high-pressure area over the Pacific Ocean known as the Pacific high.

During the summer season, inasmuch as the surfaces of the continents are heated more than ocean surfaces, there is a well developed low over Asia and a less developed low over the North American continent. The Aleutian and Icelandic lows are not so well developed as in the winter season, and, finally, the subtropical Bermuda and Pacific highs are well developed. According as these principal individual centers of action depart from their normal intensity and normal position during a given period, we have a corresponding departure from normal of the circulation pattern, and of the mean air movement, over the Northern Hemisphere. Such a displacement and changed intensity of the major prevailing air currents results in displacements of the principal frontal zones, or zones of interaction between the Polar and the Tropical air currents. This means, in other words, that the zones of maximum storminess, or storm tracks, are shifted from their normal position, with resultant persistent anomalies in the fields of all the meteorological elements. To illustrate, a year ago last winter the unusual development and westward extension of the Bermuda high during the latter part of December and most of January was reflected in the abnormal warmth in the eastern United States; and the frontal zone of interaction between the Bermuda high and the Continental high stagnated over the Ohio valley, giving rise to extremely excessive precipitation and floods in that area during most of January.

Another outstanding feature of the general circulation pattern during the winter of 1936-'37 was the replacement of the ordinarily well developed Aleutian low by a persistent high-pressure area. In this case the mild maritime air which is usually found over the north Pacific was displaced toward the west and the entire Pacific coast was dominated by air of colder origin and the western half of the continent was dominated by abnormally cold Polar continental air masses. As a result, snows instead of rains occurred along the Pacific coast and each storm was accompanied by outbreaks of cold continental Polar air. On the other hand, the Icelandic low was persistently present and overdeveloped, with the result that storms were unusually severe and persistent over the north Atlantic and on the northwest coast of Europe.

The second objective, that of finding empirical forecasting methods, presented a more difficult problem. Doctor Willett has found that the large subtropical high-pressure areas, the Bermuda high and the Pacific high, tend to dominate the general circulation. In view of this primary dependence of the complexities of the general circulation on the subtropical centers of action and inasmuch as surface conditions in the subtropics change but little, it would appear appropriate to relate the essential control factors to upper levels of the atmosphere. The appearance of the general circulation patterns over the surface of the earth is probably, therefore, merely an indirect expression of the high altitude effects. Unfortunately vertical soundings of the atmosphere are far too few at present to permit of adequate investigation of effects of the upper air over the entire Northern Hemisphere. The very regions from which aerological data are most needed are uninhabited. However, recent advances with radio meteorographs, which are carried by balloons and transmit observations to the ground automatically, definitely indicate that adequate data may be available in the near future from these regions. These meteorographs have the added advantage that stratosphere heights may be attained

and soundings made in all types of weather. Such performance is not attainable by means of airplane flights.

The line of attack which seems to offer most hope of further progress in the long-range forecast problem must be based on the investigation of the mechanism by which a given circulation pattern is established, maintained, and terminated. This involves the whole vital question of the interaction of the troposphere and stratosphere in atmospheric changes. About this interaction just enough is known at present that its full significance is coming to be generally recognized. The very fact that definite anomalous patterns of the general circulation are observed to persist for long periods of time is in itself an indication that there must be some system to a given set of control conditions. This encourages the belief that it should eventually be possible to gain sufficient information of the controlling factors that such persistent anomalous meteorological conditions may be reliably forecast.

WINTER WEATHER

While this preliminary work was being carried on, certain physical-meteorological investigations along lines that appear applicable to long-range forecasting had been started in the Weather Bureau under the special research fund. Mr. H. Wexler, of the Weather Bureau, started the investigation of the building up of the domes of cold air in northern Canada which move southward to form the winter cold waves of the United States. He found that the coldness is caused by, first, cooling of a very shallow layer of the air by contact with the cold snow surface and, second, after the temperature near the snow surface has reached a certain minimum which can be calculated from the given conditions, the temperature of a large section of the upper atmosphere starts to cool off with it. In this way, the low temperature can be spread upwards to form the deep, cold currents that are observed.

The formation of the Polar continental air is accomplished mainly through radiation processes, the upper air above the cooled surface layers radiating its heat and acting upon the energy radiated outward to space by the snow surface in such a way that the downward-radiated heat from the atmosphere is absorbed at the snow surface and there re-radiated to space. This reradiated energy, however, is at wave lengths that are not absorbed in the atmosphere. Consequently it passes on through to outer space. Thus the upper air loses heat in radiation by way of the snow surface. The process was not only explained, but was also expressed in quantitative form to show the number of clear, sunless days required to reach a certain temperature and depth of cooling. Since the formation of the Polar continental high usually takes place in air that has recently come from the northern Pacific through Alaska to Canada, the conditions could be applied to this type of air in a manner approaching long-range forecasting calculations covering a period probably not exceeding ten days or possibly two weeks.

In order to obtain additional information on the process and to test the applicability of certain hypotheses which are being formed, soundings of the upper air by airplaine and radio meteorographs at Fairbanks, interior Alaska, were conducted the past two winters. The first winter the Canadian government coöperated in the establishment of a station for similar soundings at Fort Smith, Northwest Territory. The Fairbanks and Fort Smith data used

in conjunction with the upper air observations regularly taken at stations in the northern United States present an excellent picture of the character of the Polar air in its three principal stages—initial formation, as represented by Fairbanks observations; full development, as usually shown by the Fort Smith data; and its final stages as a cold wave in the northern part of the United States, as represented by data from soundings at Fargo, N. Dak., and Sault Ste. Marie, Mich. To obtain additional information of the radiation processes, measurements of outgoing radiation from the surface were made with a special type of black-body pyranometer.

The problem of the release mechanism and the determination of the direction in which one of these cold fronts will move is being studied in coöperation with the Meteorological Division of the Massachusetts Institute of Technology. No very definite results can be reported as yet.

SUMMER WEATHER

From the work already done, it appears that summer weather conditions in the United States are dominated by the developments in the warm oceanic areas of high pressure, or anticyclones. Practically all evidence points to the hypothesis that these warm anticyclones are dynamically created, that is, they are of the nature of great eddies in the general circulation over the earth as a whole. It seems logical that the approach to a solution of the problem should be from a study of the dynamics of air currents. Certain features of circulations such as those in the atmosphere can be simulated in the laboratory by fluid experiments in tanks. In tracing the path of the fluid particles, coloring matter is injected into the fluid in these experiments and certain types of "flow patterns" are noted for given sets of conditions. In the free atmosphere we can trace out the flow patterns by following the course of what we might term "tongues" of high water vapor content which follow well-defined paths through the atmosphere. By means of a network of simultaneous daily upper air soundings such as we have in the United States, the nature of the circulations at the upper levels can be traced in the paths of moisture.

Professor Rossby, head of the Division of Meteorology of Massachusetts Institute of Technology, has found that the so-called isentropic chart, which considers the movement of the air particles in both their horizontal and vertical components, offers the best means of mapping the circulations of the atmosphere. Striking agreement between atmospheric flow patterns as evidenced by the tongues of moisture on the isentropic chart and fluid flow patterns in rotating tank experiments performed at Massachusetts Institute of Technology have been found and this has permitted mathematical solution of the simpler types of flow problems. This branch of the Special Research program has been going on only since last fall and it is a little too early to state the results. In general, it has been found that the atmospheric circulation has more of an eddying character than previously was supposed. The first part of a rather comprehensive publication presenting these recently developed concepts of atmospheric behavior is now in the press.

The research that has been carried on by Doctor Rossby, Mr. Wexler and Mr. Namias on rainfall and isentropic flow patterns is an excellent piece of work along the line of developing rational physical hypotheses and then test-

ing them for validity as well as is possible with the existing data. Results of their work leave a vivid picture of a mechanism in one's mind, whereas ordinary climatological methods of presentation are somewhat lacking in suggestiveness. Their work contributes an important step in the direction toward a dynamic meteorology and climatology. As additional years of upper air data of a more comprehensive nature become available, further refinements are to be expected. If we can discover the forces that control the shifts and that determine the size of these tongues of moist and dry air, we may have a key to longer-range forecasts of precipitation and relative humidity than are possible on the basis of existing knowledge.

The work that Doctor Willett of Massachusetts Institute of Technology has done in studying the Northern Hemisphere charts is also a step toward the understanding of broader changes in the weather pattern.

The isentropic chart permits an analysis on one chart of current weather conditions in components of all three dimensions—the two surface dimensions on which synoptic weather maps are based, and the third, or vertical dimension of upper air observations.

SOLAR PHENOMENA AND OZONE

Another far different type of investigation has to do with variations in solar activity as they may affect the atmospheric circulation. Special attention is now being given to the question of atmospheric ozone as a possible link between solar activity and changes in the circulation of the atmosphere, by Doctor Pekeris of Massachusetts Institute of Technology. The atmosphere contains a small percentage of ozone, so small that measurements of changes in amount and distribution of ozone content are difficult to make. However, these changes in ozone content of the upper atmosphere appear to be significantly associated with weather conditions observed at the surface of the earth. Measurements made thus far, mostly in Europe, show that the ozone content of the atmosphere is at a minimum near the surface center of a warm anticyclone or warm high-pressure area and at a maximum on the rear side of well developed low-pressure systems. Ordinarily the greatest quantity of ozone is observed in high latitudes, the least near the equator. Current measurements of ozone content would give the meteorologist a clue to the origin of these upper air masses. If the ozone content is high, a polar origin is suggested; if the content is low, the upper air no doubt came from the tropics.

Furthermore, it is known that ozone is a very active substance in affecting the radiation at wave lengths mostly in the ultra-violet region of the spectrum. It is considered possible that the solar radiation at these wave lengths, which appears to be variable, is connected with atmospheric changes, the ozone acting as a connecting link.

A survey of present knowledge of atmospheric ozone is being made with a further development of ideas as a definite goal. We are expecting to obtain regular ozone observations at one point at least in this country before the present fiscal year is over. These ozone measurements will be made in cooperation with the University of Rochester and New York University. It is likely that correlations between weather conditions and ozone content of the atmosphere in this country will be somewhat different from those obtained in Europe.

This investigation has been both preceded and accompanied by a project in coöperation with the Harvard Astronomical Observatory. Doctor Menzel is developing an instrument for measuring the sun's corona without waiting for an eclipse to block out the sun and make the corona visible. Plans are under way for attaching this instrument to one of the larger telescopes in this country. It is possible that variations in the sun's corona, as well as variations in the spectrum produced by the corona, may be more readily subject to accurate measurements than the variations in total solar radiation as made by Doctor Abbot.

FIVE- AND TEN-DAY FORECASTS

A new project has been started at Massachusetts Institute of Technology this fall to investigate the possibility of making five- and ten-day forecasts of certain elements of weather somewhat along the line of approach used by Doctor Baur of Germany. Mr. Page is to contribute to the statistical aspects of this investigation in coöperation with several members of the staff at Massachusetts Institute of Technology who will be responsible for the synoptic, isentropic, and air mass analysis phases of the project.

CONCLUSION

The problem of increasing the accuracy and timeliness of forecasts of yield per acre of important crops involves consideration (1) of the relationship of weather and plant observations to yield—crop-weather research, and (2) of the possibilities of longer-range weather forecasting than is practicable on the basis of our present understanding of meteorology. The immediate objective of our research program is to get the best trained scientists available in this country working intensively on this two-fold program—meteorology and agrometeorology.

It is the purpose to direct, insofar as possible, the most promising meteorological research into lines of development that could have a bearing on the general problems of short- and long-range weather forecasting. This emphasis on an understanding of the physical forces involved is an essential background for statistical studies of observed phenomena. In the long run, it is expected that the combined approach of the physical and statistical methods will produce the best results in the development of practical methods of longer-range forecasting and will increase the accuracy of the shorter-period forecasts.

The Use of Complex Numbers in Field Mapping

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Complex number theory is a very powerful tool in the art of field mapping. It should be especially so in the hands of electrical engineers, who generally are well acquainted with complex numbers through their study of alternating current theory. Field mapping technique is not only important in the solution of electrical problems, but it is applicable to many other branches of science as well, as is shown in a paper by Doctor Weber (*1*).

By the use of complex numbers, field plots of simple boundary conditions can be made quite easily and simply. The simplest of these boundary conditions is that of two charged planes of equal potential meeting at an angle. Since fields between more complicated boundaries usually contain the above case as one or more elements, a thorough knowledge of the effect of the angle of intersection on the form of the field and the variation of the field strength near the intersection should be a great aid to the mapper's judgment when, because of complicated boundaries, it becomes necessary to map fields by the freehand method.

The method is not limited in its application, however, to the class of problems just mentioned as it can be used for plotting fields in regions formed by several intersecting planes. Furthermore, the boundaries do not have to be at the same potential. When the fields are very complicated the mathematical solution becomes very cumbersome, but whenever practical problems can be idealized into sufficiently simple boundaries the method possesses some useful advantages. Frequently graphical and mathematical methods can be combined.

The complex numbers used in this paper obey the same rules and laws as the complex numbers used in alternating current theory.

It will be assumed that the fields treated in this paper are uniform along any line drawn perpendicular to the plane of the page, and it will also be assumed that the charge lies only on the boundaries. The fields therefore obey Laplace's equation in two dimensions.

If F (z) is an analytic function of the complex variable, $z = x + jy$, it has the following relations among its derivatives $\frac{\partial F}{\partial x} = \frac{dF}{dz}$; $\frac{\partial F}{\partial y} = j\frac{dF}{dz}$ and is a solution of Laplace's equation.

FIELDS SET UP BY TWO CHARGED INTERSECTING PLATES

The solution of Laplace's equation which satisfies the boundary conditions for this class of problems is $F(z) = Kz^n = K(x + jy)^n = U + jV$ where $n = \frac{\pi}{a}$, a being the angle of intersection. By assigning various values to U and V and plotting on rectangular coördinate paper the values of x and y as governed by the equations thus formed, the field can be mapped. In certain cases it

is better to use polar coördinate paper. This method is described in a previous paper by the writer (*2*).

When the conducting planes meet at 90° set $K_1z^2 = K_1(x + jy)^2 = U + jV$ from which $K_1(x^2 - y^2) = U$, and $2K_1xy = V$. Setting $V = 1$, $2K_1xy = 1$, which is the equation of the equipotential curve marked $V = 1$ in figure 1.

Likewise setting $U = 1$ gives $K_1(x^2 - y^2) = 1$, which is the equation of the flow line marked $U = 1$ in figure 1. Assigning values 1, 2, 3, etc., to U and V gives a series of equations from which curves that divide the region between the planes into curvilinear squares may be calculated and plotted.

If the two planes had intersected at 180°, the equation would obviously have been $K_2z = K_2(x + jy) = U + jV$ which, when subjected to the above treatment, gives the series of horizontal and vertical lines shown in figure 2.

It is desirable to investigate the effect of the angle of intersection on both the field form and the field strength. In order to do this some reference conditions must be chosen. These conditions will be taken such that in the two previously described field plots and in all the following which have to do with only two intersecting planes, the field strengths at three units of length measured along the lower plane from the vertex to the right as indicated by the scale accompanying the figures shall be equal.

Since the x component of field strength on the lower boundary plane is zero, the field strength at $x = 3$ in figure 1 becomes $-\frac{\partial v}{\partial y} = -2K_1x$ or $-6K_1$. Since the reference conditions require that this must be equal to the field strength in figure 2, $6K_1 = K_2$. Arbitrarily choosing $K_2 = 2$, $K_1 = 1/3$, and the mapping equation for the field shown in figure 1 becomes $(1/3)z^2 = U + jV$.

When the angle of intersection is 60° as shown in figure 3, $K_3z^3 = K_3(x + jy)^3 = U + jV$. From this equation $V = K_3(3x^2y - y^3)$, and $U = K_3(x^3 - 3xy^2)$ from which $-\frac{\partial v}{\partial y} = -3K_3x^2$. Setting the field strength at $x = 3$ equal to that of the field shown in figure 2, $27K_3 = 2$ or $K_3 = 2/27$ and $(2/27)z^3 = U + jV$ is the equation to use for plotting the field shown in figure 3.

The field set up at the edge of a charged plane, as shown in figure 4, can be mapped by means of the equation $\sqrt{48z} = U + jV$. The strength of the field on the plane and three units of length to the right of the edge is the same as that of the field shown in figure 2.

The function of z used in plotting the field of figure 5 is given by the equation $3\sqrt[3]{3}(x + jy)^{2/3} = U + jV$.

Figure 6 shows the variation in field strength on the lower boundary with distance from the vertex for all the previously described cases. The field strength corresponding to that of the field mapped in figure 2 is taken as 100 percent.

FIELDS OF OTHER BOUNDARIES

The foregoing discussion might lead the reader to the conclusion that the mapping function to be used for mapping a given field has to be discovered by chance. Fortunately such is not the case, for by use of the Schwartz-Christoffel transformation one can find the mapping functions for complicated boundary conditions, and is limited only by the complexity of the mathematics.

This transformation is discussed by Jeans (*3*) and more recently by Miles Walker (*4*).

The equations used to map the fields shown in figures 7 and 9 were obtained by use of the Schwartzian transformation.

Figure 7 shows the field of a charged slot infinitely deep. Figure 8 shows the field of two oppositely charged semi-infinite horizontal planes separated by an infinitesimal thickness of insulation at the origin. Figure 9 is the field produced by a charged semi-infinite vertical plane placed a finite distance above an infinite horizontal plane of opposite charge.

Solutions to engineering field problems by use of complex numbers have appeared in comparatively recent literature. They have been used by Palmer (*5*) in the calculation of capacitance, by Dow (*6*) and Fry (*7*) in vacuum tube problems, and by Douglas (*8*) in the calculation of end-connection reactance.

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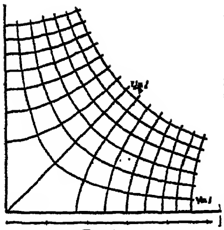


Fig. 1

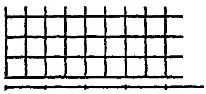


Fig 2

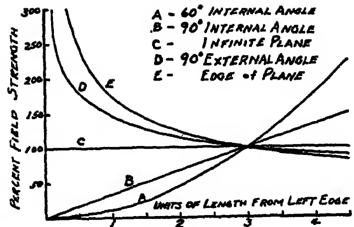


Fig. 6

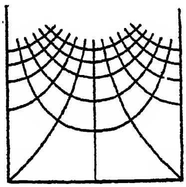


Fig 7

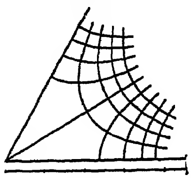


Fig. 3

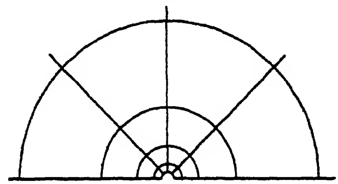
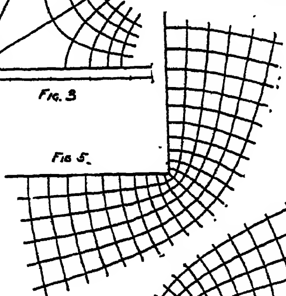
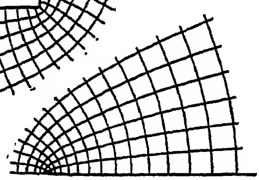


Fig. 8

Fig 5





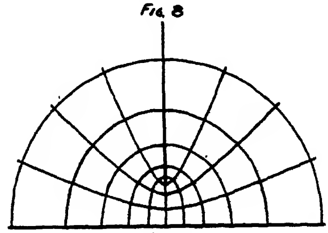


Fig. 9

Figure 1; $\frac{1}{8}z^2 = U + jV$
Figure 2; $2z = U + jV$
Figure 3; $2/27z^3 = U + jV$
Figure 4; $\sqrt{48z} = U + jV$
Figure 5; $3\sqrt[3]{3}\, z^{2/3} = U + jV$
Figure 7; $z = j\ \cosh^{-1}(U + jV)$

Figure 8; $z = E^{U+jV}$

Figure 9; $z = 2j\ \cosh\dfrac{U + jV}{2}$

The Magnifying Power of a Telescope for Objects at Close Range

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The magnifying power of a telescope is a function of the distance P from the objective lens to the object viewed, as well as of the focal lengths of the lenses (fig. 1).

Magnifying power as here used is defined as b/a, where b is the angle subtended by the final image at the eye, and a is the angle of the object. In the derivation of the equation F/f, which is usually given in textbooks as the value of the magnifying power, the angle a is measured at the center of the objective lens, at a distance P from the object. If we assume that the angle is small, then a equals y/P, if y is the linear size of the object.

If we also assume that the focus is adjusted so that the final image is at a considerable distance, then b equals z/f. The magnifying power equals b/a equals z/f divided by y/P equals zP/yf. Now the ratio z/y equals Q/P, since the sizes of image and object are proportional to their distances from the lens. Substituting Q/P for z/y,

(1) $M = Q/f$.

If the lens equation $1/Q + 1/P = 1/F$ is solved for Q, its value is: $Q = PF/(P-F)$. Substituting this value for Q in (1),

(2) $M = F/f\ [P/(P-F)]$.

Equation (2) shows that M is a function of the distance P. It is usually assumed that P is infinite. In this case $Q = F$, and (1) reduces to the usual form:

(3) $M = F/f$.

If the object is not at infinity, equation (2) gives a more accurate value of M than equation (3).

It can be proved (proof not given here) that $Q/f = D/d$, where D is the diameter of the objective lens, and d is the diameter of the eye-ring, which is the image of the objective formed by the eyepiece. Substituting D/d for Q/f in equation (1),

(4) $M = D/d$.

The measurement of D and d gives an alternative method for finding the magnifying power. This method is subject to the same limitation of accuracy that is inherent in equations (2) and (3). If the telescope is focused for infinity, (4) gives the correct value of M for that distance, but if the telescope is focused on a near object, (4), like equations (1), (2) and (3), gives a wrong value.

If the magnifying power of a telescope focused on a near object is to be computed, a formula is needed in which the angle a is measured as close to the eye as possible. Let us assume that it is taken at z, a distance Q farther from the object than before. Then $a = y/(P + Q)$, and $M = z\,(P + Q)/yf = Q(P + Q)/Pf$. Substitute for Q its value $PF/(P-F)$ as indicated above,

(5) $M = F/f\ [P^2/(P-F)^2]$.

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Since the distance from z to the eye is usually negligible compared to Q, equation (5) is sufficiently accurate for most cases. However, if objects at very close range are to be viewed, a further correction is possible, and may be desirable. If a single convergent lens is used as an eyepiece, as is often done in elementary laboratory experiments, the distance from z to the eye-ring is approximately 2f. If the angle a is taken at the eye-ring, $a = y/ (P + Q + 2f)$, and the equation for the magnifying power is:

(6) $M = F/f\ [P^2/ (P\text{-}F)^2 + 2f/ (P\text{-}F)]$, for a simple eyepiece.

For a Ramsden eyepiece the distance from z to the eye-ring is about 1.5f, instead of 2f, because of the overlapping of the equivalent planes from which f is measured. Substituting this value,

(7) $M = F/f\ [P^2/ (P\text{-}F)^2 + 1.5f/ (P\text{-}F)]$, for a Ramsden eyepiece.

If a Huygens eyepiece is used, the distance z d is about 1f, and

(8) $M = F/f\ [P^2/ (P\text{-}F)^2 + f/ (P\text{-}F)]$, for a Huygens eyepiece.

For a single divergent eye-lens, used to secure an erect image, as in opera glasses, the distance from z to the eye is negative, because the eyepiece must be placed between the first image z and the objective lens. The position of the eye is uncertain, but should be as close to the lens as possible, in order to secure the maximum field of view. Usually it is not possible to place the eye against the lens, and we may take the distance from z to the eye as ½f. With this value, the equation becomes:

(9) $M = F/f\ [P^2/ (P\text{-}F)^2 - \tfrac{1}{2}f/ (P\text{-}F)]$, for a divergent eyepiece.

In order to test these equations, the magnifying powers of several small telescopes were measured at various distances. The method used was direct comparison of the magnified image, as seen through the telescope, with the object itself, as seen with one eye looking alongside the telescope. The object used was a scale held vertically. This position was used because it was found that "drifting" of the image due to involuntary eye-movements was much less troublesome than with a scale held in a horizontal position. The focus was adjusted so that the image was coincident with the object. An idea of the accuracy obtainable may be gotten from the fact that various trials usually checked within about two or three percent.

The table of magnifying powers at the end of this article shows measured values of M for three telescopes, compared with values calculated by some of the formulae given above. The formula used in each case is indicated in the table. The magnifying power at infinity was obtained by finding the ratio F/f from measured values of these focal lengths. They were measured by the precision method described in Houstoun's Treatise on Light, first edition, pages 74, 75.

Let us assume that the distinction between a telescope and a compound microscope lies in the relative magnification produced by the objective lens. For a telescope the object is located beyond 2F, and the first image is smaller than the object. For a microscope the object is located between 2F and F, and the first image is larger than the object. The same instrument may be used as either type, and the cross-over from one type to the other occurs when P equals 2F. At this point there is no distinction between telescope and microscope. According to this interpretation the last row of figures in the table of magnifying powers shows the result of using a telescope (No. III) as

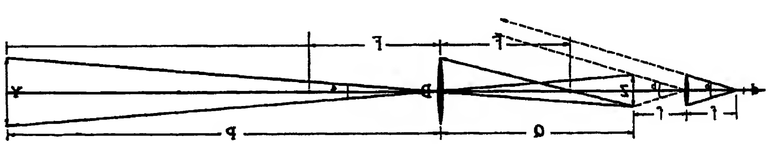
a microscope, for P equals 20 cm., which is less than 2F, which is 24 cm. Note that equation (7) gives the magnifying power in this case, as well as in the preceding "telescopic" cases.

CONCLUSIONS

Equation (3) gives accurate results for the magnifying power if the object is a great distance away. Equations (2) and (4) are satisfactory for moderate distances. Equation (5) gives good results for any finite distance except for extremely close range with very short telescopes. Because of its greater simplicity, equation (5) is to be preferred to equations (6) to (9) for short-range work in most cases. It may be found useful in checking the experimental values obtained by students, and in finding the focal lengths of multiple-lens eyepieces, from measurements of M and F. Equations (6) to (9) are likely to give the same results as (5) in most cases, because the second correction term will be negligible. For telescopes number I and II in the table of magnifying powers, (5) gave just as good or better results than (8) and (9), respectively. Equations (6) and (7) may find some utility in laboratory work, as illustrated by telescope No. III in the table.

TABLE OF MAGNIFYING POWERS

Telescope.	F cm.	Eyepiece.	Equation.	P cm.	M calculated.	M measured.
I	52	Huygens...........	(5)	infinity	24.5	....
I	52	Huygens...........	(5)	1650	26.2	25.5
I	52	Huygens...........	(5)	500	30.4	30.5
I	52	Huygens...........	(5)	300	36.0	36.0
I	52	Huygens...........	(5)	150	57.2	57.0
II	10	Divergent..........	(5)	infinity	4.0	....
II	10	Divergent..........	(5)	1760	4.0	4.0
II	10	Divergent..........	(5)	620	4.1	4.2
II	10	Divergent..........	(5)	170	4.5	4.5
II	10	Divergent..........	(5)	100	4.9	4.9
III	12	Ramsden...........	(7)	infinity	3.625	....
III	12	Ramsden...........	(7)	1000	3.7	3.7
III	12	Ramsden...........	(7)	200	4.2	4.2
III	12	Ramsden...........	(7)	100	4.84	4.9
III	12	Ramsden...........	(7)	50	6.6	6.7
III	12	Ramsden...........	(7)	25	13.9	14.0
III	12	Ramsden...........	(7)	20	22.7	22.0



The Solarized Latent Photographic Image [1]

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When light is allowed to fall on a photographic plate the silver bromide in the emulsion is altered in some unknown way because a reducing agent or developer is able to darken the silver bromide exposed to light more rapidly than that which has not been exposed. We say that the light has produced a latent image because it is invisible to the eye but susceptible to certain reducing agents. Our problem is to determine the nature of this change and of what this latent image consists. A direct approach to the study of its intimate nature has not yet been achieved. However, a careful examination of its tangible manifestations will bring forth facts which will eventually aid greatly in the formation of an hypothesis or theory.

The solarized latent photographic image is one of these manifestations. It may best be defined by means of the Hurter-Driffield characteristic curve. In figure 1 this curve is divisible into three periods. In the first period the density of the latent image is approximately proportional to the increase in the exposure. With prolonged exposure the second period is reached in which the density is proportional to the exposure, *i. e.*, the reciprocity law is obeyed in the interval. Passing on to the third period it will be observed that less and less density is added for each exposure until, finally, a point is reached where there is absolutely no increase in density. When the exposure is continued beyond this point a decrease in density results. If the exposure is increased further the density does not decrease to zero; instead, a curve is obtained which contains a series of maximum and minimum points. This portion of the curve is called the region of multiple reversal or solarization, and it resembles the damped vibration curve found in electricity.

In figure 2 the full line curve displays the eight reversals of the latent photographic image which were obtained by exposing extra fast, dry Hammer plates to a light intensity of 0.00012 foot-candle for 27,652 minutes. The data upon which this curve is based were obtained by the method of Reardon and Griggs.[2]

Now let us approach the problem of the formation of the latent photographic image by attempting to account for the shape of this reversal curve. Experimentation leaves no doubt as to the existence of a sensitivity-promoting substance other than silver bromide distributed as specks or nuclei amongst the grains. This substance is most probably silver sulphide which was formed during precipitation and subsequent ripening of the emulsion. With any normal exposure, it is these specks which form the reduction nuclei; the only action of the light is to change their condition in such a way that they become susceptible to the action of the developer. These nuclei are scattered haphazardly amongst the grains according to the laws of chance; only grains

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1. Section of dissertation submitted to the Faculty of the Graduate School of Saint Louis University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.
2. Reardon, A. J., and H. P. Griggs, J. O. S. A., 24, 1934, 331.

which have at least one nucleus will be developable. The sensitivity of these nuclei is not equal. All the nuclei in an emulsion may be divided into classes of varying sensitivity. There will be a few nuclei which are very sensitive and a few which are very insensitive. It seems reasonable to assume that the relative number of nuclei having any given sensitivity follows a Maxwellian distribution. Toy[3] studied four sizes of grains in a photographic emulsion and concluded that: (1) a set of large grains is more sensitive than a set of small ones, (2) the characteristic curve for small, less sensitive, grains has a greater slope than that for larger ones; *i.e.*, the ratio of the intensity which just changes all the grains to that which just causes the smallest possible change is greater the larger the grain size.

Employing these experimental findings of Toy, let us classify the grains in our emulsion as to sensitivity. All the grains which are rendered developable by an exposure time up to the first maximum will be placed in class one. The second class will include the grains rendered developable from the first maximum to the second, etc. The slope of the curve which represents one particular class of grains will depend upon their sensitivity. Suppose we assume that five separate grain classes were employed in the production of the eight reversals shown in figure 2, and let the dotted curves in the figure represent these grain classes. In making this assumption we arbitrarily cause a new set of grains to become active at each maximum point. Consequently, different times of exposure are necessary to bring the various grain classes into activity. The slower the grain class the longer is the exposure time required. As we pass from one maximum to the next on the reversal curve, the sensitivity of the grain classes, which have hitherto been active, is decreasing; therefore the greater will be the slope of the characteristic grain distribution curve. These five dotted curves are one possible picture of this situation. If the ordinates of these curves are added together, the curve which may be passed through the resulting points is the full line reversal curve.

Experiment has shown that the latent image is formed about sensitivity centers as nuclei in the silver halide grain. These nuclei may be specks of foreign matter upon the surface of the halide crystal or even within the crystal,[4] or they may be found upon the edges and corners of tabular polyhedral grains. These grains have been shown to consist of a system of gelatin, silver halide, water and salts. The gelatin exerts a stress upon the crystals imbedded in the emulsion. Two types of mechanical strain may be said to exist in the emulsion because of this gelatinal stress. One type, the internal strain, is due to the gelatin particles which are distributed throughout the grain. The other, or external strain, is exerted by the gelatin which surrounds the grains. The degree of developability of the latent image most probably depends in some way upon the combined action of these strains.

Perfect crystals are known to have absorption bands, hence they may be expected to react only to frequencies within certain limits and might not be disrupted by the vibratory action of the incident radiation. When an imperfection, such as a strain, is introduced into the crystal lattice the possibilities of absorption and vibration will be changed; that is, the freedom of vibration of the atoms and molecules in the crystal lattice will be altered in these regions

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3. Toy, F. A., Phil. Mag., 44, 1922, 352.
4. Poindexter, F. E., J. O. S. A., 21, 1939, 59.

of strain. Furthermore, one might expect regions of varying degrees of strain within the crystal lattice, due to the presence of sharp corners, specks of foreign matter, flaws and faults, which would also cause a variation in its response to the action of light.

Let us assume that the incident light sets up vibrations in a crystal which is imbedded in the photographic emulsion. These vibrations may cause the crystal to crack along lines of strain, thus rendering the silver bromide compound less stable because the exterior surface may be a silver bromide compound with gelatin while the interior is pure silver bromide. Andresen and Lüppo-Cramer[5] showed that exposed and unexposed silver bromide are reduced at the same rate by the developer; however, when a binding material, such as gelatin, is employed there is a decrease in the rate at which this reduction takes place. The cracking of the crystal then simply admits the reducing agent to the pure silver bromide in the interior and thereby increases the developability of the crystal. When a maximum number of crystals are opened a maximum density is obtained. This corresponds to the first maximum point on the curve. With prolonged exposure the strain in the crystal is gradually released and the pressure of the gelatin forces the molecularly smooth parts of the crystal back together. When a maximum number of cracks have been closed or when perfect crystals have been formed the developer reduces a smaller amount of pure silver bromide; therefore, a reduction in density results, and consequently reversal. A minimum density will be reached, but this minimum will not take on the value zero because not all the cracks will be closed. With continued exposure the incident radiation will set up vibrations along the lines of strain in other crystals which vary in sensitivity from those already affected and have a different number of specks. This action, together with a probable slight development of new cracks in the previously shattered crystals, results in a second rise in the density-log of exposure curve. When these crystals and the new cracks which are found in the first group are shattered as completely as possible, a second maximum is obtained.

This cyclic process of maxima and minima may be considered as continuing simultaneously with the exposure or until all the crystals containing sufficient strains have been exhausted, *i. e.*, until all the different grain classes have been rendered developable. When this point is reached the variations in the shattering of the crystals and recombinations will have ceased and, we might finally reach a point beyond which no amount of increase in exposure would give a greater density. This is similar to the Channon effect[6] in which a light of feeble intensity produces a low photographic density which cannot be increased by increasing the exposure.

In closing, the author wishes to express her appreciation for the assistance given her by Dr. Franklin E. Poindexter, of the Physics Department of Saint Louis University, who suggested and directed this research.

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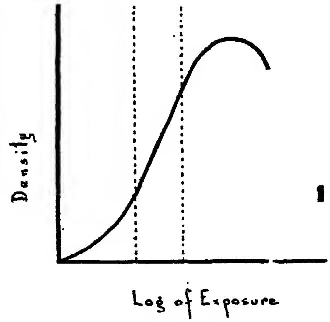

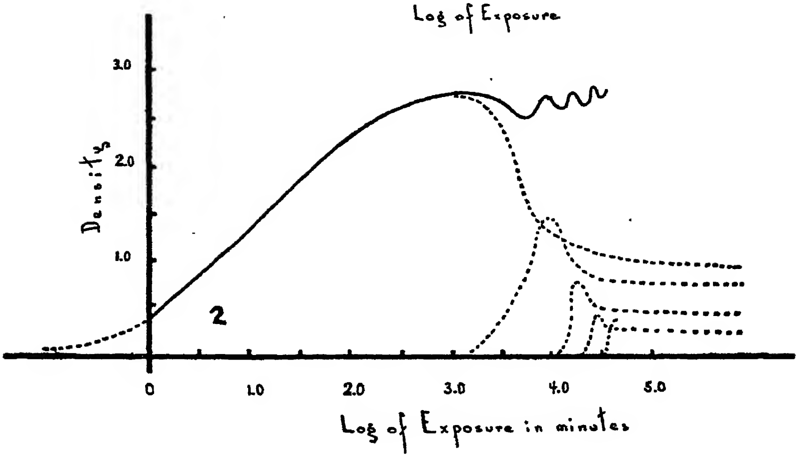

FIG. 1. Hurter-Driffield characteristic curve for a photographic emulsion. The dotted lines divide the curve into its three periods.

FIG. 2. The full-line curve displays the eight reversals which were obtained by exposing an Extra Fast, Dry, Hammer Plate to an intensity of .00012 foot-candle for a period ranging from 1 to 27,652 minutes. The dotted curves are theoretical representations of the five grain classes which took an active part in the formation of this curve.

A Study of Children Exhibiting Pattern Loss During Performance of a Mental Test

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Observation of children who were taking intelligence tests of the Binet type at the Wichita Child Guidance Center has revealed occasionally a form of disability which we came to label "pattern loss." The disability was most evident in connection with the problem-solving situations in the test. That these children grasped the problem when it was presented, and formed a solution pattern normal for their chronological age became evident when they embarked upon a procedure which should have resulted in success. But somewhere between the beginning of the problem-solving procedure and its culmination the pattern was lost, confusion overwhelmed the child and the solution of the problem became impossible. Closer observation of these cases revealed that the apparent loss of pattern was in reality a too-rapid unfolding of the pattern in the mind of the child. The tempo of actual accomplishment could not keep pace with the rapidity with which the pattern of adjustment progressed, and before accomplishment took place there was so much discrepancy between the inner plan and its expression in material form that confusion disrupted the performance and prevented success. The failures caused by this disability resulted in a lowering of I. Q. which was misleading, because it was evident that the child was able to form plans which would have proved satisfactory for his age level had he been able to carry them out. The difficulty did not involve a faulty attention span, because these children uniformly exhibited an attention span normal for their age level in scope and duration. Another peculiar phase of these cases was that this pattern loss was intermittent. Their organization capacity seemed to fade in and out at rather rhythmical intervals. This became especially noticeable during the interview period, when they would exhibit periodic confusion of pattern in their conversation. Long incidents often did not reach a conclusion. Short incidents could be expressed to the point of completion of the idea involved. This gave a chracter of incoherency to their conversation. Again it was evident that this was not a failure of attention, because the child was just as engrossed in the conversation and its subject matter after the pattern broke as before, but a conversation with one reminded the interviewer of the experience of watching reflections in a pool suddenly shattered by the ripples from a thrown stone. The pattern of the reflection would form again only to be dissolved and broken up by another surge of ripples.

These cases were rare, but after a few had been discovered we were able to recognize their peculiar and characteristic behavior during tests and interviews. We labeled them "intermittent pattern loss" cases for want of a better name. It became apparent also that these children shared certain other characteristics, and during the past year we assembled all these cases, seven in number, and arranged the known facts about each one for purposes of comparison. See Table I.

Trans. Kansas Acad. Science, Vol. 42, 1939.

Attention is called to the following similarities. Six children were pre-adolescent, but of school age, at the time of the first contact. H was contacted again during adolescence, by which time he had been diagnosed as psychotic by medical examination and had spent time in a private institution. B-2 was contacted at frequent intervals from the time he was twenty-five months old, but pattern loss did not become evident until he was nine years old. They all have I. Q.'s below 90. They all have a history of poor health through childhood and each has at some time received medical treatment for glandular imbalance or calcium deficiency, except two brothers who had not received treatment, but who exhibited hyperactivity and over susceptibility to fatigue. They all had poor vision. Six of them had been fitted to glasses. The youngest had not been examined by an opthalmologist. Six of the seven showed confusion in spatial orientation. H was never tested for this. One of the most striking similarities is the ambidexterity of five out of the seven This is a much higher incidence of ambidexterity than is shown by the general population of this age level. All of them were retarded in their reading efficiency and none of them read above third-grade level, although some of them were above third grade in school placement. All of them showed very poor facility in arithmetic. Five of them had one overdominant parent. H had a mother who had been in the state hospital at Larned. On the whole the intellectual level of the parents was high. Five of the seven had efficient siblings and in three cases the sibling efficiency was of a very high order. None of them showed any marked retardation in age of learning to walk or talk. Other characteristics seem to show no significant likeness. The progress of these cases, so far as it has become known to us since examination, may be briefly stated as follows. B^{-1} was given a program of glandular therapy motor and spatial orientation reëducation, a confidence-building program in the home environment and tutoring in academic subjects. Two months later her father reported improvement in motor coördination, ability to grasp relationships in arithmetic and adjustment in home life. During a visit at the Center it was observed that she was able to hold organization patterns for a longer period at a time. The parents and the school both had noted improvement in this respect. No later report has been received.

G was given glandular therapy, spatial orientation retraining, taken from school for a term and given private tutoring and then placed for a term in a private school. At the end of the period with the tutor, G showed strengthening of her personality, normally sustained pattern organization and a rise of six points in I. Q. Her eyesight had improved and she had regained some use of her left eye. Habitual right-handedness had spontaneously established itself. At the end of the period at private school, which had been accompanied with a certain amount of emotional strain, the pattern loss was slightly in evidence again, and her I. Q. had again dropped to where it was at the time of first contact.

C was given calcium and glandular therapy and a visit on a farm kept her free from strain of any sort for the summer. She was given puzzle therapy and spatial orientation reëducation. After the summer her health was improved, pattern loss was less acute and her I. Q. had gone up three points. Glandular therapy was continued through the fall and she was placed in the Sunshine Room at school. This furnished a school environment unusually free

TABLE I

Intermittent Pattern Loss.

Case and Problem.	School placement.	Age.	IQ.	Physical health.	Eyes.	Ears.	Spatial.	Hand.
Retarded........................ B 1	4 B	10-1	66	Adrenal cortex comp. or mild encephalitis.	Poor; given glasses.	O. K.	Pattern loss; marked.	Ambidextrous.
Retarded.............. G	6 B	12-4	73 Herd. 82	P. M. temperature; double pneumonia when small; hypothyroid.	Poor; given glasses; total suppression of left eye.	O. K.	Pattern loss; marked.	Ambidextrous; reversions.
Retarded speech; personality....... C	3 A	9-2	75 A. 91 early Binet 91	Poor; has taken calcium; diagnosed as hypothyroid and hypopituitary.	Wears glasses.	1. Overacute. 2. Dull in one ear.	Very little; some reversion.	Right.
Reading....................... S 1	1 B	6-6	85	Underweight, hyperactive.	Poor.	O. K.	Pattern loss.	Ambidextrous.
Reading........................... S 2	1 A	7-8	80	Poor; underweight; hyperactive; easily fatigued.	Poor; wears glasses.	Poor.	Confusion reversion.	Ambidextrous.
School retarded; psychotic......... H	3 d	9-5 14-2	80 73	Poor; has had thyroid.	Has worn glasses.	O. K.	....	Right.
B 2....	4 B	9	89	Poor; is receiving glandular therapy; injured at birth.	Poor, wears glasses; total suppression of left eye.	Definitely hard of hearing.	Confused.	Ambidextrous.

	Academic facility.		Home.	Siblings.	Developmental history.	Motor.
	Reading.	Arithmetic.				
	Third grade.	Very poor; no concept.	Father very dominating physician; mother efficient.	Older brother efficient.	Walked 16 months; talked 18 months.	Retard.
	Third grade.	Poor; no concept.	Parents intelligent; mother dominates.	Two brothers, very efficient; older.	Walked 13 months; talked 9 months; bottle fed.	No report.
	Second grade.	Very poor.	Parents brilliant; foster child; dominating mother.	Efficient brother.	Birth injury.	Retard.
	Very poor.	None.	Unstable parents; dominating father.	Older brother, less efficient.	....	Adv.
	None.	None.	Unstable parents; dominating father.	Younger brother more efficient.	Full term; poor health; walked 1 year; talked 2 years.	Adv.
	Poor.	Grade level, ungraded.	Mother psychotic; much dissension in home.	Only child.	Breech pres. hernia, accidents; walked 18 months; talked 2 years.	Normal.
	Poor.	Poor.	Both parents very intelligent; mother especially efficient.	Two brothers younger; both efficient.	Premature child; walked 18 months; talked 2 years.	Retard.

from emotional strain. Early in January she was reëxamined at the Center. There was no evidence of pattern loss and her I. Q. had gone up eighteen points. Her mother stated "Living with her is like living with an entirely different child from what she was."

In the case of S^{-1} and S^{-2} the Center was not able to interest the parents in seeking an adequate medical program. The only program they were interested in was one of remedial reading teaching. This failed to produce any results. Contact was lost with the case after a few months.

At the time H was discovered to be showing the pattern loss phenomenon he was fairly well established in an opportunity room. Although a medical diagnosis of psychosis had been obtained institutionalizing did not seem immediately necessary. The examination was made at the request of his father, who thought he might be permitted to go into a regular school grade. Contact with the case was terminated at the end of the examination period. There is no way of knowing how long this child had been exhibiting pattern loss, what relationship it bore to his other multitudinous difficulties, nor how the pattern loss may have been affected by the measures taken for the other troubles.

B^{-2} has been under observation at the Center since he was an infant and has only recently displayed pattern loss. This occurred at about the same time that the total suppression of use of the left eye was observed. This eye condition had been in progress for over a year according to the results of tests made with the Betts telébinocular, but had not reached the stage of total suppression until the last test made. Because of the pattern loss the parents were asked to have the glandular balance investigated and therapy was found to be indicated. The general program is at present in process of being formulated, but it is already apparent that it must include release from emotional strain, and play therapy to relieve social and sibling hostility.

The phenomenon of pattern loss is more like a mild manifestation of delirium than anything else. Like delirium it is a condition in which the subject's inner processes of organization are at variance in their tempo with the march of outward events. As in delirium the subject goes into a situation with an appreciation of the outward event, but during the development of the event becomes confused and disoriented to it. There is a possibility that this disorientation can be attributed primarily to the difference between inward and outward tempo. It seems reasonable to assume that the inner tempo is influenced by some physiological condition possibly involving metabolic processes. Whether the peculiar effect produced is the result of a speeding up of the organizational processes which puts them out of kelter with the sensory processes, or whether it is brought about by something which directly changes the relative balance of the tempo of reception and organization of sensory processes is matter for conjecture. The relative tempo of receptive and organizational processes is an interesting factor to consider with reference to the problems involved in establishment of what is called "close touch with reality."

Also intriguing is the prevalence of ambidexterity, the incidence of monocular vision and spatial disorientation in these cases with its suggestion of a relationship between the conditions of bilateral function and the synchronization of pattern tempo with that of outward events.

Skin Conductance Changes Occurring During Mental Fatigue

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The following presentation is but a brief report of an apparent relationship between skin conductance changes and continuous mental work. The present report is based upon a graphic study of continuous mental work product and concurrent skin conductance changes. The study is a part of a larger problem in which several physiological reactions were observed under conditions of mental work.

An important aspect of the problem of mental work and fatigue is the study of the physiological processes that operate concomitant with mental work. The central problems of such a study are whether, and in what manner, the physiological processes reflect the mental performance decrement. Is study of the physiological processes that operate concomitant with mental function in any way reflected in the physiological reactions? Do the physiological functions mark the energy debt of the mental operations? Are their action in any way compensatory for loss in mental performance output? Do the physiological functions reveal any new knowledge of the nature of mental fatigue, or of the nature of variations in mental performance? The present report may be regarded as a glimmer of a direct answer to these questions.

The greater number of the physiological studies that have been made in an effort to study physiological changes of mental work have been studies of changes which result from the work, but not of changes which occur during and in the course of the work. In order to answer some of the above questions, it seems more profitable to observe processes concomitant to mental work—continuous recording of such changes during the work.

In the large study an effort was made to study physiological changes as they appear in blood-pressure, pulse rate, respiration, level of skin conductance, galvanic skin response, and vaso-dilatation-constriction.

The mental task was continuous manual responding to serial presentation of colors. Bills' psychergometer was used. The subjects operated a keyboard of five keys corresponding to the five colors which were automatically presented. Each time the subject pressed the correct key the next color was presented. The colors were randomly arranged upon a steel tape. The subjects were first practiced until they reached an average rate of about ninety colors per minute.

The experimental condition consisted of fifty-five minutes of mental work, preceded and followed by ten minutes of rest. There were three control conditions necessary to isolate the sensory and motor components of the mental function. The first control condition was that of rest for one hour wherein the subject either relaxed or fell asleep. The sensory control consisted in observing the colors automatically presented for fifty-five minutes, the subject assuming as passive an attitude as possible, making no attempt to recognize the presented colors. The motor control consisted in continuous tapping

Trans. Kansas Acad. Science, Vol. 42, 1939.

of the keys of the psychergometer at a rate set by a metronome adjusted to correspond to the subject's mental work rate. The subject was blindfolded while he continuously tapped the keys for fifty-five minutes. The sensory and motor controls were difficult to maintain because monotony induced sleep which was not desirable.

During all conditions the physiological reactions were recorded continuously by means of a behavior research photopolygraph. The level of skin conductance and the galvanic skin responses were measured by means of standard calibration of the records made available by the behavior research resistance box. For the purposes of this study, the galvanic changes were measured in terms of ohms of resistance.

Mental work and fatigue in this study were operationally defined in terms of the product decrement: *i. e.*, the number of color discrimination responses and frequency and length of blocks per unit of time. The criteria of frequency and lengths of blocks, so-called mental refractory periods, serve best in demonstrating the product decrement, increasing in number and length as mental work continues. For the present study, the poorest criterion for the mental product decrement was used, that of the number of responses per unit of time. The mental work product was plotted in units of fifteen seconds. To conserve bromide paper, alternate five-minute records were made during the experiment.

The results of the two subjects' records which form the basis of this report are as follows. The continuous mental work showed a definite decrement in product in terms of the number of responses per fifteen seconds. The product decrement was about five responses per fifteen seconds less for the last five minutes of work than for the first five minutes. There is an apparent concommittance in increase in level of skin resistance as mental work efficiency decreases. During the prework rest period of ten minutes there is a gradual increase in resistance which is interrupted by a radical decrease in the level of skin resistance for the first two or three minutes of mental work. This drop in resistance is accompanied by an initial high level of work. From this point on, there is a gradual increase in the level of skin resistance, though interrupted by numerous galvanic skin responses. There is an apparent suggestion that the G. S. R.'s are in some way related to the changes in efficiency of the mental task. The larger G. S. R.'s appear to be definitely associated with the periodic increases in mental work product. The fluctuations in the galvanic curve must be in some way related to the processes occurring during the mental work performance, for they are not consistently present in the galvanic curve describing the level of skin resistance during the control period of fifty-five minutes of relaxation or rest; further, they are not present in the pre- and post-work rest periods of ten minutes. After completion of work, the galvanic curve steadily inclines to higher resistance.

The galvanic curve of the level of skin resistance during the sensory and motor control conditions also appears distinct from that obtained during the mental work. In the case of the two subjects reported, the level of skin resistance during these conditions showed a more radical increase in resistance than during the rest control. The final resistance levels in these two conditions approached the levels of resistance usually found in sleep. The galvanic curves under these conditions do not manifest the persistent occurrence of G. S. R.'s.

Following Darrow's[1] interpretation of the galvanic phenomenon, we may briefly interpret our results in the following way. The results, as they appear, fit the established relationship between changes in bodily tension and changes in skin conductance. If the level of palmar skin conductance is related to the psychological dimension of apprehension and attention, then the steady reduction in energy in continuous mental work should be associated with an increase in resistance, for the more apprehensive and attentive a person is the lower the level of palmar skin resistance, while conditions which approximate relaxation and sleep are accompanied by a very high resistance. The periodic changes in efficiency in mental work are accompanied by periodic changes in attention and apprehension, these same changes resulting in G. S. R.'s.

The results and the interpretation in this study follow closely the observations made by Sears[2] in his study of the galvanic responses occurring during arithmetical work.

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1. Chester W. Darrow, and Alfred P. Solomon, Galvanic Skin Reflex and Blood Pressure Reactions in Psychotic States, Archives of Neurology and Psychiatry, 32:273-299. 1934.

2. Richard Sears, Psychogalvanic Responses in Arithmetical Work, Effects of Experimental Changes in Addition, Archives of Psychology, No. 155, 1933.

Psychological Problems Involved in the Private Employment of Nonschool NYA Young People in Ellis County

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This is not a statistical or normative study. It is a descriptive study based upon individual findings. In it we hope to throw some light upon certain psychological aspects of unemployment. The subjects consisted entirely of youth on the regular National Youth Administration Work Project rolls of Ellis county, Kansas. NYA work projects employ nonschool youth who come from certified relief homes. By special arrangement with the Fort Hays Kansas State Psychological Clinic, certain of these youth, representing a fair sampling of the entire NYA roll of the county, were assigned to the clinic for supervision of their work and to receive vocational guidance.

Information and social histories of the subjects were obtained from the office of the county director of social welfare, NYA offices, schools, clinical case studies of recorded material resulting from conferences with the individual cases, employers, social workers, and others who have had professional interests in the cases, in addition to information obtained directly from the subjects themselves.

The jobs at which these youths were put to work in the clinic were designed to give prevocational training as far as possible. They consisted essentially in a progressive series of job situations to which the worker was required to adjust, the situations being set up with each job increasing in difficulty in the light of the psychological diagnosis.

The clinic attempted to get a survey of types of jobs available in Ellis county as well as maintaining an active employment agency; not waiting until vacancies were reported through the usual channels, such as the reëmployment office, but having someone constantly interviewing probable employers so as to anticipate vacancies. The plan worked out comparatively well until attempts were made at placement. At that point the problems with which this paper deals arose as obstacles to the successful completion of the project.

The possibility of jobs available, in private employment in Ellis county, either for boys or girls was limited. For example, about the only outlet for boys of this type was to work as a day laborer on a farm during seasonal demands, at odd jobs in a garage, as delivery boy in a store or at some other menial task. Work in a private home as a maid was about the only available channel in which a girl could find private employment. There were a few jobs available in restaurants and in stores; however, they required employees to have some high-school education. The average schooling of our group was the seventh grade, most of them having gone to parochial schools in inland villages which did not maintain high schools. They belonged to a peculiar ethnological group which has been described elsewhere (*1, 2, 3*).

Let us consider a few of the principal factors involved in this situation.

1. *Scarcity of jobs available*. The scarcity of jobs available was the first problem encountered. This problem, however, was trivial when compared with

the fact that youth refused to accept the few jobs that were available because the meager wages received made them little more than slaves.

2. *Wages*. In private employment as a house maid, in Ellis county, the average wage received varied from three to five dollars per week. The NYA wage, was $3.50 per week. The hours worked in a day in private employment failed, in most instances, to conform to the number of hours worked in a day on NYA. This can best be illustrated with a case.

Case A. Female, age 18, has seventh-grade education, placement director found employment for her in a private home. She quit after working two weeks. When questioned as to why she quit, the following story was told: "I went to work at eight o'clock in the morning, washed the breakfast dishes, the supper dishes from the night before, cleaned the house, prepared the noon meal, washed the dishes from the noon meal, if there was any ironing I worked at that until it was time to get supper, then I prepared that meal and went home. I did this for seven days a week for two weeks and made $6. On NYA I work a total of only four days, seven hours a day, out of two weeks and make $7. Why shouldn't I quit? Wouldn't you?" This was a typical reaction of the majority of cases placed.

3. *Migration of workers*. The scarcity of jobs in the immediate community spurred the Clinic and the NYA officials to make greater efforts to locate jobs outside the community. This represented an attempt to solve the problem by migration of workers, a type of solution on which the nation has made some interesting experiments. These efforts largely met with failure in this community because parental influence and close community ties were so strong with this ethnological group that most youth refused to accept employment outside of our immediate vicinity. Let us illustrate with a case.

Case B. Female, age 19. Her "ambition" was to earn money for clothes. Her parents wanted her to help financially at home. They also would have liked to see her marry. B was interested vocationally in a waitress job or an office job. The placement director reported a job—"curb-hopping"—at an outdoor light-drink stand in a neighboring town. B refused to consider it since there were too many boys and men around and she was afraid it might cause trouble with her "boy friend." Later the placement director reported a vacancy in a hotel dining room with fairly satisfactory wages and working hours. Clinician approached B about this vacancy. B refused as her folks didn't want her to be away from home. B also said, "Why should I take this job, other girls on NYA don't work at other jobs?" This same girl listed on a questionnaire, among other things, NYA and the WPA sewing room as types of vocations she would like to enter for a life work.

4. *Established attitudes toward relief*. Parents of these youth were in the certified relief rolls and were receiving or had received assistance recently. These boys and girls have been reared during their early teens in homes in which the families have received public relief. Some such statement as the following is a natural one for these young people to make. "Father had relief, why shouldn't I?" These young people have never been employed except on relief projects. Acceptance of relief represents no step downward in their social scale. To them relief is something to be expected regardless of need. Any means necessary to secure this relief are justified. They look upon it as

legalized graft. The majority of them lack the intelligence to realize that it is graft and think of it as a natural endowment of nature, free to all who can stake their claim and have it certified.

The stigma which many people attach to the acceptance of relief is not present to any great extent in the group studied. After working with this problem in individual cases for considerable time the psychological clinic recommended a policy of associating some degree of stigma with the acceptance of relief among these young people. The authorities coöperated with this suggestion (to use our staff conference phraseology, we tried to make relief "stink"). The fact that relief was considered a natural right rather than an emergency measure was well established by the following case:

Case C. A boy, 23 years of age, six feet two inches tall, weight one hundred ninety pounds, was employed on NYA. He had offers of jobs in oil fields, but turned them down, as he said they were "too dangerous." In a psychological study of the case it was found that the parents bought his clothes for him and furnished gasoline for the car he used. His NYA income at that time was approximately $3.23 per week. He lived at home and got his meals there, but made no contribution to the family budget. The principal item for which he used his NYA money was liquor. The remainder of his money was spent for shows and other amusements. However, this fellow was fairly well persuaded that he should receive NYA assistance.

5. *Attitudes of employers and employees.* In order to bridge the gap between relief and private employment the clinic adopted a policy of requiring each young person to make three personal applications for private employment during each two weeks pay period. After each application they were requested to report on the outcome of the interview. Many of these personal applications proved successful and the youth received employment. The follow-up division of the clinic interviewed both employers and employees in such situations in order that we might have their attitudes toward each other which would enable us to view both sides of the employment issue and plan our system of training in accordance with this information.

Following are some statements made by employers to the representatives of the clinic regarding prospective employees: "I can't make the youth work." "You hire one and he flies into the work with a great show of energy and in two weeks he has slowed down to such an extent that a child could do as much." "I can't afford to hire these boys when I can get better men for the same wage. I can't afford to train them." "He can't be trusted." "He can't meet the public." "She has a bad reputation."

The following are typical statements made by employees regarding prospective employers. "He's too hard a man to work for." "He asks too many questions that are none of his business." "I had to work all night and had only fifteen minutes in which to eat my lunch." "That work is too dangerous, I might get hurt." "No one else will work for that guy, why should I?"

6. *Government reports.* Government reports and administrative red tape are of such a nature that they tend to destroy morale. Relief clients as a rule develop the "get by" attitude. As a rule they know very little, and care less, about the reports that governmental officials are required to send in to the central office. Those of us who have had experience in writing govern-

ment reports know that in writing them one does not develop a reputation for veracity.

The following case is an example of this "get by" attitude:

Case D. D's father brought him into the relief office with the intention of sending him to the CCC camp. The interviewer noticed that D looked rather old for such an appointment and made the statement that the age limit was twenty-five. After a moment's hesitation the father said, "All right, he's twenty-five." Figuring from the birth date it was found that he was nearly thirty. His application was refused and it was suggested he send one of his other boys, mentioned by name, as he would qualify. To which the father answered, "Oh, I couldn't do that; he is the only one who will work, I need him at home."

From clinical evidence we have briefly surveyed certain important major psychological problems involved in the placement of nonschool NYA youth into private employment. They are as follows: Scarcity of jobs available that are suitable for the type of youth we have to place; the insufficiency of the wage scale; the refusal of youth to accept employment away from home because of strong parental influence and close community ties; established attitudes toward relief as a natural right; the attitudes of employers and employees in regard to each other, and the breakdown of morale due to the influence of administrative red tape.

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An Experimental Study of Attitude Toward the Public School System

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Much is being said and written today, both in praise and in criticism, of the public schools. According to some individuals most of the world's woes today are to be accounted for in terms of the school's failure to recognize and perform its functions properly. Others are apparently just as firm in their belief that public education is the only thing that has enabled civilization to survive complete catastrophe.

Some years ago an educational group undertook to catalogue statements on both sides of the question and concluded, among other things, that opinion seemed to be rather evenly divided on the matter, with the extremes of praise and criticism being about equally represented. As the writer read the various statements, however, he could not help feeling that such extremes of opinion, either pro or con, did not represent the feeling of people in general, and that a canvass of the general population would probably reveal the attitudes of most people to fall nearer a neutral point than to either extreme. This was, of course, mere conjecture, but it seemed to be the most logical conclusion to draw in the light of already available evidence concerning public attitudes on other issues. Most important, though, was the fact that it posed a problem which seemed worthy of investigation, and it was in an effort to obtain some experimental evidence on it that the data here being reported was collected.

While not as reliable as some other techniques, the questionnaire approach to the matter appeared to be the quickest and easiest, so it was decided to construct a questionnaire for measuring attitudes toward the public schools, using the Thurstone method. Accordingly, a large number of statements representing all degrees and variations of attitude toward the school system were collected from many different sources, while still others were concocted from the writer's own imagination. Some such items, of course, failed to meet such logical criteria as freedom from ambiguity, conciseness, simplicity, and the like, but after these were eliminated, a group of 135 reasonably acceptable and understandable statements remained. These were then typed on separate slips of paper and submitted to 150 psychology students for evaluation. In keeping with the Thurstone method they were instructed to sort the statements into eleven piles representing variations in attitudes from those extremely favorable to the public school at one end of the scale, to those extremely antagonistic to this institution at the other end of the scale. It should be noted that in sorting the statements the judges were not asked to express their own opinions, but rather to indicate the quality of opinion they felt was expressed by the various statements.

The results were tabulated so as to show where every judge placed each statement. From this data a graph was drawn for each statement, and the point at which a cumulatively plotted curve crossed the fifty percent line was

Trans. Kansas Acad. Science, Vol. 42, 1939.

called the scale value of the statement. Since the scale covered a range of eleven points, scale values smaller than 5.5 indicated that the statement was favorable to the school, and those larger than 5.5 were unfavorable. The first and third quartiles of the curve were also calculated, and the difference between the two was determined. This difference is the Q value or measure of ambiguity. If a statement is quite ambiguous, the different judges will place it over a wide range on the scale, and the Q value will be correspondingly high; if the statement is concise and uniform in the meaning which it conveys to all readers, they will place it at approximately the same position on the scale, and the Q value will be correspondingly small.

A final list of 40 statements of opinion was selected from the original list of 135 opinions for inclusion in the final scale. The selection was made with consideration of the criterion of ambiguity (as determined by the Q values), the scale values, and by inspection of the statements. Statements were selected whose scale values were more or less evenly distributed over the entire scale from one to eleven. This inspection was similar to the first one, in that wherever two statements had the same Q value and scale value, the shortest, simplest and most concise statement was selected. Thus the experimental scale as finally presented to the several hundred subjects for actual voting was made up of the statements which had the smallest Q values with the most uniformly graduated series of scale values. The scale, together with the accompanying instructions and scale values, is given here. The questions on the title page were inserted so the scales could be classified for various comparisons and correlations.

EXPERIMENTAL STUDY OF ATTITUDE TOWARD THE PUBLIC-SCHOOL SYSTEM

This is an experimental study of the distribution of attitude toward the public schools. You will be asked to read a list of statements about the school system and to endorse those that express your own sentiment. Let your own experience with schools determine your endorsements.

1. Occupation.. Age............... Sex.......................
2. Underline the amount of schooling you have had: Less than 8th grade, 8th grade, high school, college.
3. How many children do you have in grade school, junior high, or high school at the present time?...................................
4. Are you a member of the Parent-Teachers Association? Yes. No.

NOTE.—No name is to be written on this sheet and no attempt will be made to obtain the name of any individual helping with this study.

Check (√) every statement below that expresses your sentiment toward the public-school system. (Note: Scale values below 5.5 are favorable to the schools while values above are unfavorable.)

Scale value

1.9 1. In my opinion our public schools are extremely influential in developing the character of American youth.

6.6 2. I believe that the public schools do not offer enough opportunities for specific trade and vocational training.

10.4 3. I think that the American taxpayers are swindled out of millions of dollars yearly for the support of that useless social ornament, the public-school system.

1.2 4. It is my opinion that our public-school system is one of the greatest forces for the preserving and promoting of desirable ideals.

5.2 5. I think that in general the public-school system is a good institution, but it has a few weak points.

7.8 6. I think our schools coddle the pupils too much.

9.0 7. I think the education received in the public schools is altogether too superficial to be of any value.

8.8 8. I think that the public schools fight progress in order to preserve their own vested interests.

0.6 9. I believe that the greatest gift of the United States to democracy is free public schools.

2.6 10. I believe that public-school education is preparatory to continuous adult learning.

10.5 11. I think the country would be better off if the schools were closed and the teachers put to some useful work.

5.8 12. I think the services of the school system are worth to society just about what they cost. Society breaks even with the schools.

2.0 13. I think the school is a place of useful instruction for both young and old, and is essential to every community.

10.2 14. I see no value in the public schools.

2.8 15. I believe that the public schools supply to the child the opportunity to learn the skills needed for business and industrial success.

8.6 16. I think too much money is being spent on the schools for the benefits derived.

9.4 17. I believe that the teachings of our public schools lead us up a blind alley; that is, they lead to nothing beyond themselves.

4.3 18. I think the schools offer the answer to the problem of educating for wise use of leisure time.

8.2 19. I believe the schools are bound hand and foot by the money interests and cannot give a truly democratic education.

1.9 20. I believe the school is a powerful agency for promoting both individual and social betterment.

0.6 21. I believe the public-school system is the greatest institution in America today.

7.0 22. I think the schools stress school subjects too much, and the vital problems of life too little.

10.1 23. I think the public-school system is a parasite on society.

5.2 24. I believe that if the public schools were brought up to date, they could contribute a great deal to social progress.

9.8 25. I regard the public-school system as a set and unchanging institution and as such it is unwholesome and detrimental to society and to the individual.

4.0 26. I believe that every child stands with equal rights before the schoolmaster's desk.

1.0 27. I believe the public schools are the greatest influence we have for good government and right living.

2.2 28. The school is the most unselfish institution in American society today.

7.0 29. I think the schools are too idealistic, both in the subject matter they teach and in the methods they use.

0.8 30. I believe that the public-school system is America's greatest social and cultural enterprise.

4.0 31. I think that a public-school education makes it possible for a person to make more money.

4.8 32. I believe the school system is all right.

8.2 33. Much of the usefulness of the school system has been outlived.

5.6 34. On the whole, I believe our public-school system is good, but it has many faults.

8.6 35. I believe that the public-school system is too radical; its teachings are too liberal.

5.8 36. In general I believe the schools are all right, but I sometimes wonder about their value.

2.8 37. I believe that the public-school system educates the people to perform their duties and obligations as citizens.

8.0 38. I think the public school spends too much money teaching frills.

2.3 39. I believe that the great advances made in the arts and sciences in America are due largely to the great public education system we have.

7.2 40. I think the public-school system needs a complete reconstruction of its curriculum if it is to meet modern needs effectively.

The scoring of any scale is a comparatively simple matter. Since we have arbitrarily adopted an origin of the scale at the favorable end of the series and established a unit of measurement, which is the equal appearing interval, we can calculate the mean scale value of all the opinions that any individual subject endorses. This means we called the score, which was measured only to the first figure to the right of the decimal place.

APPLICATIONS OF THE EXPERIMENTAL SCALE

As has already been pointed out, this investigation was originally undertaken in an effort to obtain some sort of measure of the attitude of people in general toward the public schools. It appeared, however, that it might be possible to obtain information that would make it possible to answer several other questions at the same time that data on the original problem was being collected. Questions which first presented themselves to the writer were:

1. Is there any difference between the attitudes of individuals who have high incomes and those who have low incomes?

2. Does membership in Parent-Teachers Associations influence the attitude of an individual toward the public schools?

3. Is there any correlation between the attitudes of husbands and wives toward the public-school system?

It is obvious that there are innumerable problems which could be considered, but these three presented themselves to the writer first. Since the work began, however, others have sprung up, some of which we are now working on.

Taking up the influence of income on attitude, we were faced with the problem of administering the necessary number of questionnaires to a random sample of the population. It is obvious that many individuals are reticent about revealing their income and still others are suspicious of any questionnaire. Several different techniques were considered, but each seemed beset with difficulties of either too much expense, time consumption, or some imposition upon the subjects. Finally we decided to ask students in general psychology to take the questionnaires home and administer a few of them to individuals in their communities who fell into the economic groups we wished to measure. We realize that this method has a possible defect in the fact that we have no absolute assurance that these students administered each questionnaire as carefully as he might have, or to individuals falling in the income ranges in which we were interested. However, we have good reason to

believe that by far the greatest portion of them administered the questionnaires conscientiously and carefully, and to the right persons. The first semester we asked all general psychology students to administer questionnaires to individuals whose incomes were less than $1,500 per annum. Second semester students were asked to administer them to individuals whose incomes were greater than $1,500 per annum. By this method we obtained data from 363 individuals in the lower group and 243 individuals in the higher group. The statistical results were:

High	Low
Mean = 3.331	Mean = 3.288
Median = 3.22	Median = 3.13
Standard deviation = .712	Standard deviation = .808

Diff. .043

S. E. diff. .053

Although the low income group is slightly more favorable to the schools than the high, this difference is not significant. Thus it would appear that income, per se, does not have much influence upon the attitude people have toward the public school.

The next question raised was that concerning the influence of P. T. A. membership on attitude. The data used in that phase of the study just described was also used here. Since there were not enough P. T. A. members represented in that data, however, questionnaires were administered by the writer and his assistants to P. T. A. groups. For this portion of the study there were scales from 477 nonmembers and 145 scales from members. It might be assumed that if the P. T. A. is doing its job well, there must be a noticeable difference between these two groups. The results showed:

Nonmembers	Members
Mean = 3.343	Mean = 3.257
Median = 3.10	Median = 2.95
Standard deviation = .844	Standard deviation = .816

$$\frac{\text{Diff.}}{\text{S. E. diff.}} = \frac{.086}{.076} = 1.1$$

Although the P. T. A. members were slightly more in favor of the school system than nonmembers, this difference is too small to be considered significant. It is possible that this difference is small because both members and nonmembers of P. T. A. organizations mix so freely in everyday life that an exchange of ideas and attitudes is quite common.

From the data already mentioned we had sixty-five pairs of husbands and wives, and the third problem we were interested in was a comparison of their attitudes. Statistical treatment here showed:

Husbands	Wives
Mean = 3.345	Mean = 3.129
Median = 3.25	Median = 3.00
Standard deviation = .839	Standard deviation = .811

Coefficient of correlation = .714

$$\frac{\text{Diff.}}{\text{S. E. diff.}} = \frac{.216}{.155} = 1.4$$

The average score for women was slightly more favorable to the school system than that of men, but even though this difference is more significant than any others studied, it is hardly significant enough to draw conclusions. However, the correlation between the husbands and wives is quite noticeable. The writer would not care to speculate as to whether this similarity of attitude is due to their constant association or whether they were mated in the first place because they did have similar attitudes. At any rate, there apparently is a significant correlation. A most interesting field for future research would be the cause of this similarity.

Returning now to our original problem of trying to find out something about the attitudes of people in general toward the school system, we find by examining the total number of 636 scales, of which 305 were men and 331 were women, that they tend to be grouped near the center, or neutral point. By far the largest number of scores seemed to lie between scale values 3 and 4, with only three scores having a scale value of 1.2 and only one have a scale value of 9.6. From this we can conclude that the "average" individual is slightly in favor of the schools, rather than being either extremely antagonistic to or extremely in favor of that institution.

The writer expects to report later upon the following problems for which he has available the necessary data:

1. Does the amount of formal education affect an adult's attitude toward the school system?

2. Does the number of children he has in school have any apparent affect on his attitude?

3. Does the individual's age have anything to do with his attitude, as measured by our scale?

No doubt in the process of this work other problems will come to light that will also be profitable and of interest.

We believe the scale will prove of real value to those individuals who direct the affairs of the school in showing them the attitude of parents, and we hope that more comprehensive studies may be built around it so that those concerned may have greater insight into public attitude.

The Knowledge of the Scientific Method Among College Students

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The most notable accomplishment of Western civilization has been the rise and practice of the scientific method. Instead of explaining phenomena in animistic, vitalistic or mystical terms, contemporary civilization has interpreted natural occurrences in terms of observable data. Indeed, while it is most commendable that civilization has advanced from a stage of belief in spirits, our Western culture with its democratic ideals cannot continue to progress unless the general public understands and uses the principles of the scientific method. The author of this article was aroused to the problem of the lack of knowledge of the scientific method by the superficiality and vagueness of the responses of students on this particular problem. Some students understood the scientific method to mean specialized techniques, such as keeping materials sanitary, being accurate in measurements, and even developing manual facility with laboratory instruments. Other students confused science with philosophy, even suggesting that religion should be more scientific. As a result of this vagueness and superficiality on the part of many students, a study was made at the College of Emporia in October, 1938, of the knowledge of the scientific method among college students.

It was not deeemed feasible to measure the knowledge of the scientific method by means of descriptions of specific situations involving the use of the scientific method. Such a test would have to be of great length because it must include a variety of situations from many different fields. For example, specific problems from the field of physical science might involve a knowledge of biology, chemistry, and advanced physics. Similarly, from the field of social studies, these specific problems in the scientific method could require a working knowledge of economics, sociology and various branches of psychology. It is obvious that the average student does not have a sufficient background including so many comprehensive fields. A test purporting to measure the knowledge of the scientific method by describing specific situations would not likely achieve validity. Consequently a test would have to be constructed on the basic principles that underlie the scientific method.

A four-point, multiple-choice, objective test was constructed, embracing the basic principles used in the scientific method. Since correct scientific terminology is necessary for straight thinking in scientific endeavors, a few items were included that aimed to test a knowledge of scientific terminology. That the test may not overemphasize some fields to the neglect of others, the instrument was reviewed thoroughly and repeatedly by instructors in biology, education, English, and geology. Each of these instructors, with one exception, holds his doctorate in his respective field. Each of these instructors was particularly interested in the teaching of scientific procedures. After such careful and repeated examinations and revisions, it is assumed that the test had a certain degree of validity.

Trans. Kansas Acad. Science, Vol. 42, 1939.

The test of the knowledge of the scientific method constructed by Dr. Robert E. Bugbee, of the College of Emporia, and the author is hereby presented. The best answer in each test item, as determined by those who ultimately formulated the test, is indicated. The individual scores, consequently, represent the number of items answered correctly.

Place the number of the best answer in the space in front of the number of the exercise.

1 1. To be scientific, you should
(1) Adopt the questioning attitude.
(2) Accept without verification the statements of others.
(3) Accept the statements that are claimed by others to be scientific.
(4) Accept the statements of those with whom you happen to agree.

1 2. The scientific method teaches
(1) To doubt all authority.
(2) To accept authority when the majority agree with it.
(3) To accept without reservation the statements of those whom you consider to be in position of knowing the facts.
(4) To accept the statements of those who claim that they are authorities.

2 3. The scientific method seeks the explanation of a known phenomenon in terms of
(1) Vitalistic or animistic forces, such as life urge, spirit, etc.
(2) Known factors composing the phenomenon.
(3) Unknown factors composing the phenomenon.
(4) Factors outside the phenomenon.

4 4. The aim of the scientific method is primarily
(1) To refute religious or philosophical dogma.
(2) To discount old or archaic ideas.
(3) To substantiate the results of others.
(4) To seek the truth.

3 5. The scientific method allows interpretation to be based only on
(1) Current opinion.
(2) Speculation.
(3) Observed facts.
(4) Tradition.

2 6. To be scientifically accurate, an investigator should seek to determine in a problem the weight or importance of
(1) Only one unknown factor.
(2) Every factor.
(3) The constant factors.
(4) The variable factors.

1 7. According to the scientific method, if a student upon repeated and accurate recheckings finds his answer to a problem to be different from that in the book, he should
(1) Conclude that the book is in error.
(2) Accept the answer in the book without further investigation.
(3) Change his procedure in such a way that the answer in the book may be substantiated by his results.
(4) Conclude that a mistake had been made in his procedure.

1 8. According to the scientific method, knowledge is gained
(1) Only by the sense organs.
(2) By intuition or "hunches."
(3) By revelation.
(4) By authority.

1 9. The ultimate and chief aim of the scientific method is
(1) To relate phenomena to natural laws.
(2) To overthrow previous conclusions.
(3) To verify what has been discovered.
(4) To discover new facts.

4 10. The teaching purpose of a laboratory conducted according to the scientific method is
(1) To teach students the use of scientific instruments.
(2) To teach students scientific accuracy and precision.
(3) To teach by object lessons what has been stated in textbooks.
(4) To teach students to be able to analyze critically into their known factors problems that are not easily analyzed in everyday life.

2 11. The scientific method seeks to find the relationships among
(1) Only the known constant factors.
(2) Both known and unknown constant and variable factors.
(3) Only the known variable factors.
(4) Only the unknown constant factors.

2 12. The scientific method demands every person
(1) Discard all previous advancements in knowledge.
(2) Accept authority with the mental reservation that authoritative statements are subject to revision.
(3) Accept authority of long standing.
(4) Accept authority that is supported by patriotic or religious feeling.

4 13. A procedure may be said to have employed the scientific method when the results upon accurate rechecking are found to be
(1) In agreement with the "hunches" of the investigator.
(2) In agreement with the previous experience of the investigator.
(3) Dogmatically agreed upon by certain investigators.
(4) More or less the same regardless of the investigator.

3 14. According to the scientific method, a person may use for a solution to a second problem the results obtained from a first problem
(1) When a few of the essential elements are comparable in both problems.
(2) When both the essential and nonessential elements are the same in both problems.
(3) When the essential elements of the second problem are the same as those of the first problem.
(4) When cause and certain effects are concomitant.

1 15. According to the scientific method, a supposition is proved
(1) When the solution is verified by observable data.
(2) When the solution satisfies the opinions of the investigator.
(3) When the solution agrees with the results of some other investigator.
(4) When the solution agrees with custom.

4 16. The scientific method must include for the final solution of a problem the consideration of
(1) As few factors as possible that the solution may become simple.
(2) Only the unknown factors.
(3) Only the known factors.
(4) Both the known and unknown factors.

4 17. According to the scientific method, conclusions are allowed only after
(1) All the cases have been studied carefully.
(2) The investigator has made a study of one dozen cases.
(3) The investigator's results are in agreement with the majority of other investigators of similar problems.
(4) Enough cases have been studied that further research does not add materially to what is already known.

1 18. According to the scientific method, the results of a situation should be directly traceable
(1) To the essential elements of the situation.
(2) To the incidental elements of the situation.
(3) To both essential and incidental elements of a situation.
(4) To neither the essential nor incidental elements of the situation.

3 19. In the scientific method, whenever certain results occur, it becomes necessary to point out as causal factors
(1) Those factors that occurred nearest in point of time.
(2) The most easily explainable factors.
(3) Those factors that possibly could contribute to the results.
(4) All the undiscovered factors that might be involved in the problem.

2 20. Problems are usually studied in laboratories because
(1) Scientists who can analyze the problems remain in laboratories.
(2) The problems are so complicated that by studying them in everyday life analysis would be difficult.
(3) Scientists and students need problems for training in the scientific method.
(4) Custom decrees that such problems be studied in laboratories.

3 21. After a person has gained eminence in a particular field, correct scientific method
(1) Encourages him to speak with authority in fields in which he has not gained eminence.
(2) Allows him to speak with authority in fields related to the one in which he has gained eminence.
(3) Requires him to refrain from speaking with authority in all fields but the one in which he has gained eminence.
(4) Demands that he does not speak about material in any field.

1 22. In scientific terminology, a law
(1) Allows no exceptions whatever.
(2) Allows a few exceptions to show that it is almost universally applicable.
(3) Must cover the majority of cases.
(4) Does not need to be descriptive of any phenomenon.

4 23. According to scientific terminology, a hypothesis is
(1) A law that has many exceptions.
(2) A disproved law.
(3) A newly discovered law.
(4) A law that lacks enough observable data to indicate its validity.

1 24. With respect to scientific advancement, scientists must
(1) Remain open-minded.
(2) Seek to substantiate their opinions.
(3) Try to refute the conclusions of others.
(4) Strive to uphold authority.

3 25. With respect to moral, aesthetic, or emotional outcomes of a problem, the scientific method, is
(1) Vitally interested.
(2) Slightly interested.
(3) Disinterested.
(4) Interested as long as human welfare is promoted.

4 26. The scientific method is applicable in
(1) Only the exact sciences.
(2) The exact sciences and the social studies.
(3) All fields.
(4) In all fields of knowledge based upon observable data.

2 27. The scientific method should use as its starting point in the solution of a problem
(1) An assumption.
(2) Observed data.
(3) A hypothesis.
(4) A statement purporting to be authoritative.

1 28. Training in the scientific method should give one
(1) A thorough knowledge of method regardless of subject field.
(2) A knowledge of all scientific fields.
(3) A comprehensive knowledge of his own field and an understanding knowledge of related fields.
(4) A complete knowledge of only one field.

4 29. The scientific method holds the scientist to a code of ethics that
(1) He thinks only of human welfare.
(2) He must not conflict with authority.
(3) He must not disrupt the social order.
(4) He must disregard what effects his results may have on human welfare.

1 30. Essentially the scientific method is
(1) A means for arriving at truth by interpreting knowledge gained through the sense organs.
(2) A technique for maintaining data.
(3) A procedure for collecting data.
(4) A comprehensive viewpoint of life.

The test was administered at one sitting to the student body of the College of Emporia. Because of absences and other interferences a total of 266 students out of a student body of 341 participated in the examination. The students were cautioned to do their best as the scores might have a bearing on their grades. The test was administered under admirable conditions. Although no time limit was imposed, nearly all the students completed the test within forty minutes.

By the use of Table I the mean scores of the four classes are presented.

TABLE I.—The mean scores of the four classes on the test of the knowledge of the scientific method.

Classes.	Number of cases.	Mean score.	S. D.
Senior	45	21.35	2.87
Junior	52	20.04	3.49
Sophomore	75	18.87	3.74
Freshmen	94	16.87	3.36
Totals	266	Av. 18.88	Av. 3.41

The progressive increase from class to class can be explained by either or both of two conditions. First, the inferior students tended to be eliminated before they reached the upper levels of college work. Secondly, additional college training very likely gave the students a better insight into the scientific method. Considerable overlapping occurred in the scores of the individual classes. Some of the freshmen scores were superior to some of the senior

scores. When it is considered that thirty was a perfect score, the mean scores did not indicate a very clear understanding of the scientific method.

After consideration has been made of the inferior performance of the freshmen students and of the fact that presumably the most capable high-school students enter college, the conclusion must be made that the knowledge of the scientific method must be meager among high-school students. When it is so frequently asserted that civilization depends upon progress developed by the scientific method, the high schools are shirking their duties in failing to train the students in the principles of science. Since a small percentage of high-school students enter college, the larger share of our population must necessarily learn these principles by informal means. The author suggests that the failure of our secondary schools to teach the scientific method correctly accounts in a large measure for the reason that the general public accepts unwarranted conclusions, and authoritative statements without reservations of any sort. In short, our secondary school population is not trained to exercise the right of individual interpretation.

At this time it may be well to indicate the ten items missed most frequently and their respective percentages of error. These percentages were derived by dividing the number of errors by the total number of students who took the test.

Item	Percentage of errors
25	65.79
9	58.64
18	56.01
8	55.25
14	52.25
7	51.50
28	49.66
30	45.86
29	45.11
2	44.35

According to the data presented above, the following misconceptions of the scientific method proved to be most prevalent among college students:

1. Belief that science must regard the ethical or moral implications of problems. This difficulty very likely arose by the popular statements that science had accomplished so much for the welfare of humanity. Consequently it was the obvious conclusions of many students that science should regard the moral implications of various problems. The author, however, takes the viewpoint that such an interpretation is outside of the field of pure science. For example, a research worker in the field of explosives is not necessarily interested in whether or not his findings will be humanely used.

2. Inability to give authority its proper place. Too frequently students rely on authority as having the last word in a problem. Frequently students are told to accept without question authoritative statements, including the opinions of textbooks, so that most students never exercise the right of mental reservation.

3. Failure to understand that most problems present a multiplicity of factors, which usually operate in varying degrees of intercorrelation. Students seem to overlook too frequently the presence of other factors that could bring about a certain result.

4. Confusion of science with philosophy. Students seem to feel that the province of science is the interpretation of life, while philosophy is relegated to the limbo of antiquated studies.

5. Failure to understand that science depends upon observation by the sense organs. Hand in hand with over-emphasis on the use of authority, with the neglect of the right of mental reservation comes the failure of the students to depend upon observation for themselves and to reach their own conclusions. It is evident that, although we emphasize scientific procedures, students have not been properly taught that the scientific method demands individual interpretation of data instead of relying upon authority.

Another problem raised by this study was whether or not students majoring in certain departments had a better understanding of the scientific method than those majoring in other departments. Since the students in the freshman class were not required to declare their majors, only the students of the three upper classes submitted their majors. The results are indicated in Table II.

TABLE II.—The mean scores of 178 upper-class students classified according to majors.

Majors.	Number of cases.	Mean score.	S. D.
English	19	21.02	2.61
Science	36	20.52	2.87
Social Science	28	20.07	4.01
Home Economics	17	19.91	2.85
Business Administration	53	19.65	3.49
Music	14	19.43	3.82
Nursing (Freshmen)	11	18.82	2.53

As may be observed, no significant differences existed between the departments in the knowledge of the scientific method of their respective students. No department could claim that the knowledge of the scientific method was the outcome of its courses of instruction to the disadvantage of other departments. These data seemed to reflect somewhat upon the outcomes of instruction in the field of science, which is popularly supposed to be the chief agent for instruction in the scientific method. Students are enrolled in laboratory courses without knowing the real reason for the existence of a laboratory. One student stated that if a certain result failed to agree with the laboratory manual, enough artifacts should be introduced to bring about the desired results. Similar criticism could be made of other departments that claim to inculcate scientific procedures. In short, the authors wonder whether or not a new approach, preferably the inductive, should not be employed in teaching the scientific method.

As another phase of this problem of the understanding of the scientific method, correlations were calculated between the individual scores on the informal test submitted and the scores on the psychological examination of the American Council on Education. As indicated in Table III, the correlations were significant for the first three classes.

TABLE III.—The coefficients of correlation between the scores on the psychological examination and scores on the test of knowledge of the scientific method.

Classes.	Number of cases.	r.	P. E.
Freshmen	71	+.5058	.06
Sophomore	58	+.6566	.06
Junior	46	+.4887	.08
Senior	26	+.2084	.13

The relatively few cases in the senior class very likely invalidated the correlation. With the exception of the senior class, the correlations between the scores on college-entrance examinations and the knowledge of the scientific method may be said to be significant. Various reasons exist for the significance of these correlations. Possibly the more intelligent students have a better approach to the solutions of certain problems and arrived at a better insight to the scientific method. Also the more intelligent are better able to generalize from specific experiences and formulated a method from their specific training in the secondary school. Another reason that must not be neglected is the fact that the more intelligent students have evolved a reading ability superior to that of the less intelligent students. Obviously a student deficient in reading ability would be at a disadvantage in answering correctly the various items of the test on the knowledge of the scientific method.

The conclusions of the previous paragraph are somewhat substantiated by the correlations between the individual scores and the scores on a reading test. The English Department of the College of Emporia administered the Nelson-Denny Reading Test to the incoming freshmen for the last three years. For this reason the correlation could not be calculated for the senior class. The results are presented in Table IV.

TABLE IV.—The coefficients of correlation between the scores on the Nelson-Denny reading test and scores on the test of the knowledge of the scientific method.

Classes.	Number of cases.	r.	P. E.
Freshmen	62	+.5668	.05
Sophomore	58	+.5930	.05
Junior	39	+.4935	.08

These correlations are also significant. In the light of comparatively high correlations between the scores on the test for the knowledge of the scientific method and the college entrance and reading examinations, respectively, a student, well prepared for college work, apparently also has a better insight into the solution of scientific problems that impinge upon him. The obvious conclusion seems to be that the student who has the capacity to develop superior reading ability also has the power to evolve a superior procedure for the solution of problems.

According to the data presented in this article, the following conclusions appear to be justified.

1. If the students at the College of Emporia are to be considered representative of the students in liberal arts colleges, it may be concluded that the knowledge of the scientific method among college students is inadequate and superficial.

2. In spite of the inadequacy of the knowledge of the scientific method among college students, a progressive increase in understanding of the scientific method is found as one proceeds into the upper levels of college instruction.

3. As evidenced by the performance of freshmen in the College of Emporia, it appears that the knowledge of the scientific method must be most meager among the pupils of our high schools.

4. No significant differences exist among the various departments of the College of Emporia with respect to the knowledge of the scientific method gained by their respective students.

5. Because of the significant correlations between college-entrance examinations, reading tests and the scores on the test for the knowledge of the scientific method, a direct relation is evidenced between preparation for college and ability to understand scientific procedure.

A Preliminary Report on the Levy Sibling Technique As Used with Children at the Wichita Child Guidance Center

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During the last decade there has been an increased amount of experimentation and research with the use of play therapy in dealing with children's difficulties. In 1937 Dr. David Levy published a research monograph entitled "Studies in Sibling Rivalry,"[1] in which he described a type of play therapy, involving the use of dolls, which he had used with great success in dealing with cases of sibling jealousy.

During the past year at the Wichita Child Guidance Center, sixteen children have responded to the Levy technique in one form or another and the procedure has been found helpful in releasing tensions in other situations as well as those involving sibling rivalry.

The Levy experimental procedure is very simple and inexpensive. With the exception of the amputation doll, which we were unable to procure, and the use of clay breasts for the mother doll we have tried insofar as possible to follow the author's directions. I quote from Doctor Levy's monograph.

"The patient is told that we are to play a game. For the game we need a mother, a baby and an older sister or brother. We use dolls to represent these —the amputation doll for the mother. The examiner says, 'The mother must feed the baby'—the baby doll is put in the nursing position on the mother doll, the mother's arms encircling it. The child is asked to name the baby and the brother or sister. The examiner then says, 'Now this is the game. The sister comes and sees a new baby at the mother's breast. She sees it for the first time. Now what does she do? Do whatever you think.' The child is encouraged with such phrases as 'Go ahead,' or 'What do you think she would do?' The experiment may be repeated several times."

On a table nearby we have various play toys which may also be used as instruments of aggression. These include a hammer, saw, cannon, gun, a toy wagon, scissors and similar destructive implements.

After the controlled situation has been utilized the examiner may then stimulate activity in various ways. Such phrases as, "When the sister saw the baby she thought, 'The nerve of that baby to be on my mother's lap' " are used. Questions as to how the sister felt, or whom the mother liked best are also permissible. The child is never told that the dolls represent himself and his family situation. The child is usually left to discover the play toys by himself. When he has discovered them we allow him to use them in any way he sees fit. If he breaks the dolls and in so doing releases his own tensions so much the better.

The child is usually given a thirty-minute play period once a week, but this is varied to fit the individual needs of the subject. The program is carried on until the child's behavior shows that he has rid himself of his hostility.

In general we have used this technique with three different groups of children. Group one included children who were referred to the Center for

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1. Research Monograph No. 2, of the American Orthopsychiatric Association. 1937.

sibling difficulties; group two, those referred for emotional problems which were found to have as a causal factor, a sibling rivalry; and group three, those children referred for general hostility to other persons, whether the persons were children or adults.

A study of the reactions of the children revealed that their approach to the Levy situation seemed in almost every case to follow a routine. First the child usually showed passivity and waited for the examiner to make a move. The second step was usually desultory play in which the child sometimes changed the situation into a "play house" situation and sometimes played the experimental situation; third, was usually play with the toys at the toy table without any overt inclusion of the dolls; fourth, a refusal to play with the dolls and a return to passivity; fifth, general hostility with the toys at the toy table, but usually not directed at the dolls. At this stage the children pounded, shot the cannon, banged and sawed the furniture. The next step was usually an active impulsion to get to the top of the ladder and remain there or leave the room entirely. Seventh step was usually release of hostility on the dolls themselves. By this time the child had usually identified the dolls overtly with his own situation. The hostility was released by breaking, cutting, or shooting the dolls or dropping them. The hostility might be directed toward all of the dolls or toward any of them. For instance, one four-year-old punished the mother only. His reasons as he expressed them were that the mother was bad. She cried and wet herself.

In almost all of the cases behavior seemed to follow this general pattern of steps in the release of the hostility. Not all of the children reached the point of open aggression against the dolls. Not all of the children followed all of the progressive steps in their reactions, nor were all of the steps usually present during any one play period, but where the steps were present they tended to follow the same order with the exception of the ladder behavior. This six-foot ladder is affixed to the wall in the playroom, and while most children of school age are interested in it only when it is a new toy to them, all of the children with whom the Levy technique was used, with one exception, seemed to gravitate to the ladder at every play session. Most of these children climbed the ladder several times during each session with the dolls. Often they would wish to remain at the top of the ladder during the entire period. With so few cases observed we are loathe to speculate as to the significance to this ladder behavior.

Since this technique has been used with only sixteen children, it is virtually impossible to give any statistical results of our use of the Levy material. In the groups comprised of the children with well defined sibling problems and those of children with emotional problems having as a causative factor a sibling jealousy, it was found that when the children were able to overcome their own feelings of repressed antagonism and "take it out" on the dolls so to speak, their adjustment to their family situations and to themselves seemed to become much more wholesome and the children themselves became happier.

Reports on the few children with general hostilities with whom the Levy technique has been used show that when the hostility was released on the dolls the child's behavior at home and at school improved.

Eventually we hope to be able to enlarge this technique into several situations which will more nearly fit children of different ages. For instance, ex-

perimentation with puppets and cartoons has shown us that in the case of older children these may be more acceptable than the dolls because of the social stigma attached to playing with dolls. Then, too, in dealing with general hostilities we have found it more helpful to set up a comparable situation for the child rather than the experimental Levy situation.

At this stage of the experiment we can only say that when the children in all three groups were able to release their hostilities on the dolls, whether those hostilities were directed toward siblings or toward society itself, the child himself has adjusted to his own problems to a much more complete degree. Whether the release will be permanent is another question which can better be answered after a longer period of observation.

An Unusual Anomaly of a Postcaval Tributary in the Thoracic Region of the Domestic Cat [1]

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The frequent occurrence of anomalies of the venous system in cats prepared for student dissection has long been recognized. McClure (1900), desiring to emphasize the frequency of this condition, selected twenty-five cats at random from the zoölogical laboratory at Princeton University and found thirty-three distinct abnormalities of the postcava and its tributaries in fifteen specimens. He grouped these under five major types. Darrach (1907) reported on 177 abnormalities that were detected in the postcava and tributaries of 605 cats.

During the past ten years some 2,000 cats have been dissected in the laboratories of the Department of Zoölogy at Kansas State College. Certain of the anomalies described by McClure and Darrach have been discovered regularly by the more alert students, who readily noted the discrepancy between their laboratory outlines and their dissections. However, a most unusual anomaly was called to my attention by a student this past semester (January, 1939). It consisted of a vessel about one inch in length and slightly more than one-sixteenth of an inch in diameter that extended from the caudal surface of the third lobe of the right lung to the diaphragm at the level of the postcava and about three-sixteenths of an inch from it. Dissection revealed that the vessel continued in the tissue of the diaphragm and entered the postcava where the superior phrenic vein is normally located. It was found after dissection of the lung that this anomalous vein originated from the union of five main branches that converged at the periphery of the lung. The vein and its branches appeared to represent an independent system for, as far as could be ascertained, there was no communication with the pulmonary vessels which were normal. In other words, this aberrant vein originated in capillaries in the lung and no doubt conveyed oxygenated blood to the postcava.

The vein was so situated that its presence cannot be explained on the basis of an atypical persistence of some temporary embryonic vessel. As far as could be determined, the vein is the superior phrenic. Its abnormal position in this specimen probably had its inception during its formation in the diaphragmatic tissue. Since the fundaments of the diaphragm and the lung are intimately associated during the early stages of their development, it is possible that the vein extended into the third right lobe of the lung and continued its development there.

The specimen was inadvertently destroyed before a more careful study could be made. The figure was drawn in part with the aid of a sketch of the dissection by Miss Annette Alsop.

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1. Contribution No. 203 from the Department of Zoölogy, Kansas State College.

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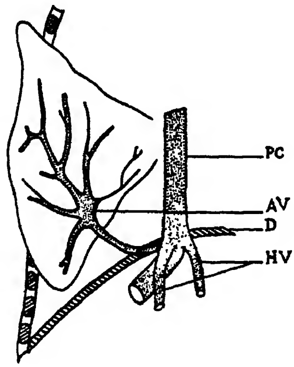

Explanation of Figure

PC. Postcava.
AV. Anomalous vein in third lobe of right lung.
D. Diaphragm.
HV. Hepatic veins.

Variation in the Snake, *Thamnophis macrostemma* Kennicott

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In this paper I have treated of a series of snakes from the plateau region of Mexico which have for nearly thirty years been placed in the species *Thamnophis megalops* (Kennicott). This concept of the species was the result of the action of Dr. A. G. Ruthven (1908), in his comprehensive monograph on the genus Thamnophis. He placed in synonymy with *megalops* the species *Eutaenia insigniarum* Cope and *Eutaenia flavilabris* Cope, together with *Eutaenia macrostemma* Kennicott. Smith (1939, p. 30), has commented on Ruthven's choice and points out that the name *macrostemma* must be used in lieu of *megalops* for this group of snakes. He says: "Kennicott's description of *megalops* precedes the description of *macrostemma* by one page; Ruthven (1908, p. 44), probably for this reason, chose *megalops* for the specific name, placing *macrostemma* in its synonymy. This cannot stand, however, for Ruthven was not the first reviser. Cope had selected *macrostemma* many years before (Proc. Acad. Nat. Sci. Phila., 1866, p. 306, 1866)."

In the material which I examined from the EHT-HMS (Edward H. Taylor and Hobart M. Smith) collection I had available 83 specimens grouped as to sex and locality as follows:

Locality	*Number females*	*Number males*	*Total*
Chihuahua	3	3	6
Durango	2	4	6
La Quemada, Jalisco	7	6	13
Magdalena, Jalisco	1	0	1
Chapala, Jalisco	15	19	34
Celaya, Guanajuato (vicinity)	2	1	3
Mexico City (vicinity)	3	3	6
Puebla, Puebla	10	4	14

These localities coincide, or very nearly so, to those localities from which Ruthven drew his material; (1908, p. 47).

In any taxonomic review it is necessary to summarize those characters that have been used as marks of identity by various authorities and to evaluate these characters as to their dependability as segregators of species or subspecies. In short, any single character must be used with its known maximum and minimum variation in mind as well as the maximum and minimum variation of allied characters and sexual dimorphism. The units of measurement must be as accurate as possible and of such a nature that they may be easily transmitted to, and applied by, future systematists.

The general characters of the genus and species may be found by referring to Ruthven (1908, pp. 8-58). I have attempted to show the variation that obtains in the series of specimens available from this collection.

The usual dorsal scale formula for the species is 21-21-19-17 or 21-21-17-17. Ruthven found a slight decrease in the dorsal scale formula towards the southern part of Mexico. In my series of specimens the following variation

Trans. Kansas Acad. Science, Vol. 42, 1939.

from the normal obtained: From Jalisco, one specimen with a count of 23-23-19-17, two with 21-23-19-17 and one with a formula of 23-21-19-17. One specimen each from Chapala and the vicinity of Mexico City have counts of 21-19-17-17; two specimens from Puebla have dorsal formulae of 19-21-17-17. A mother (EHT-HMS. No. 4887) and brood of fifteen young from Chapala includes five individuals with dorsal scale counts of 21-21-19-17 and eleven individuals with counts of 21-21-17-17. It is interesting to note that the maximum and minimum of this character for this species is not represented in this single brood.

Cope (1884, pp. 167-194), in separating *Eutaenia insigniarum* and *Eutaenia flavilabris* from *Eutaenia megalops,* stated that the first row of dorsals were smooth or nearly so in these two forms. I found no specimens in which the keeling was completely absent for it invariably prevailed posteriorly; among the brood of number 4,887 the keeling was absent on the anterior part of the first dorsal row, and but faintly evident on the posterior part of this row. Among the more northern specimens the keeling might be present or absent anteriorly, dim or distinct, but in every instance it varied irrespective of locality or sex.

The positions of the dorsal and lateral light lines seem to form a relatively constant character. *Usually* the dorsal light line is one and two half scale rows in width, while the lateral stripe is found upon the third and fourth dorsal rows anteriorly and on the third or third and second rows posteriorly. The Chihuahua and Durango specimens show an invading of the dorsal light line by the two adjacent rows of fused black blotches until only one scale row is covered by the median dorsal light line; in some cases the edges of the scales of this median row are black-margined. The lateral stripe is uniform in appearance and plainly evident.

The La Quemada specimens possess a dorsal light line which varies in width from one and two half rows to seven and two half rows, it is not bordered by a black margin except upon the interspaces; this latter marking the lateral extension of the dorsal light line which otherwise is similar in color to the rest of the dorsal scales, however, it is usually a shade or two lighter. The lateral light line occupies the usual position and is better defined from the bordering colors than is the dorsal line.

The adult Chapala specimens show no evidence of a dorsal stripe. instead the whole dorsal region is a uniform dark bluish color; however, the brood of specimen number 4887 show a very sharply defined dorsal light line, which in every individual was one and two half rows in width and bordered laterally by a series of dark blotches. In the adults the lateral light line is evident, but not as well differentiated as it is among the members of the brood.

The specimens from the vicinity of Mexico City and Puebla show a well-defined dorsal light line one and two half scales wide, and the lateral light line is clearly defined upon the third and fourth rows as usual.

The amount of variation in the numbers of labials is so small as to preclude their use as characters demonstrating variation within the species. The Chapala brood shows only one instance where the supralabial count is below 10, while the infralabials were uniformly 8-8. Other specimens from various localities show variations of 8-7 to 8-9, and conversely, from the usual 8-8 formula of the supralabials and variations of 9-10 to 11-10, and conversely,

from the usual infralabial formula of 10-10. Many of the increases and decreases were directly caused by abnormalities in the formation of the labial scutes and whether or not these abnormalities are genetic is not known. There is a probability that there may be a slight decrease in the number of labials toward the south, but this could only be determined upon examination of a large series of specimens.

Cope (1884, pp. 167-194) states the *Eutaenia insigniarum* has no occipital spots; Ruthven (1908, p. 11) states, "there are nearly always two proximate bright spots upon the parietal plates." The specimens I examined all showed the presence of parietal spots except a few which are so badly damaged that the presence or absence of the character is a matter of conjecture.

TABLE I.—Variation in the ventral scutellation of the males.

LOCALITY.	Ventrals.			Subcaudals.			Prop. tail length.
	Min.	Max.	Average.	Min.	Max.	Average.	
Chihuahua	164	172	166	84	86	85	.247
Durango	160	166	163	....	....	....	....
La Quemada	158	163	160	73	81	76	.235
Chapala	159	169	165	69	84	78	.234
Celaya	168	168	168	78	78	78	.210
Mexico City	168	169	168	74	77	75	.232
Puebla	162	165	164	71	75	73	.229

TABLE II.—Variation in the ventral scutellation of the females.

LOCALITY.	Ventrals.			Subcaudals.			Prop. tail length.
	Min.	Max.	Average.	Min.	Max.	Average.	
Chihuahua	156	164	159	68	68	68	.213
Durango	153	164	159	....	....	....	....
LaQuemada	155	157	154	67	72	69	.222
Chapala	155	164	159	62	73	68	.215
Celaya	156	158	157	61	64	62	.209
Mexico City	151	155	152	67	67	67	.204
Puebla	151	160	157	61	67	65	.208

Plate I shows the distribution of the scale counts arranged as to sex on the basis of the total ventral and subcaudal scutellation. In reading this plate it should be born in mind that a figure 2 should be placed before each number to make them read 210, 211, 212 and so on. Among the Chihuahua specimens there is one male with a total ventral scale count of 258. The Chapala specimens are divided into two groups, the upper group being composed of adults and the lower group consisting of the mother, number 4887, and her brood.

The mother has a total count of 219 scales, thus showing a variation of thirty-two scales between the highest male and the lowest female scale count found in this one brood. Ruthven (1908, p. 52) gives the greatest variation between the highest male count and the lowest female count, irrespective of locality, as twenty-six scales. This series of specimens demonstrate a definite shortening of the tail towards the southern part of its range with the associated reduction in ventral scutes.

TABLE III.—Variation in the proportionate head length.

Locality.	Males.			Females.		
	Min.	Max.	Average.	Min.	Max.	Average.
Chihuahua	.316	.333	.322	.286	.350	.317
Durango	.286	.333	.318	.250	.308	.279
La Quemada	.267	.333	.296	.212	.333	.280
Chapala	.204	.357	.310	.265	.357	.309
Celaya	....	....	....	.286	.333	.310
Mexico City	.286	.318	.299	.286	.312	.297
Puebla	.300	.333	.312	.286	.357	.314

For the comparative length and width of the head, in order to avoid confusion, I have adopted a *fronto-rostral index* which consists of the width of the anterior end of the frontal plate divided by the distance from the posterior end of the frontal to the anterior end of the rostral. Table III shows the results obtained with this series of specimens. I am satisfied that this index serves a purpose in comparing the head measurements, although further data is needed to prove whether or not it will be of value in differentiating the various forms of this species.

The characters involving scutellation of the head have shown that this species is a very homogeneous form throughout its range. However, as in the case of Ruthven, I find a very definite geographic grouping by color pattern alone:

First: The Chihuahua and Durango specimens show the dorsal and lateral light lines plainly. The dorsal line, usually one and two half rows in width, in these specimens is invaded by the lateral blotches until the two half rows are entirely obliterated. The scales of the center row are provided with narrow dark borders, while a narrow black stripe borders the median line for its entire length. There are two series of lateral black blotches, the upper series in contact with the black stripe, the second series of blotches alternating with the former; occasionally the corners of the black blotches of the two series are in contact. The light scales between these dark spots carry a series of white (probably red in life) flecks on the edges which extend into the interspaces.

Below the lateral line is the usual series of dark spots which extend from the first and second dorsal rows to the adjacent ends of the ventral scutes.

The head and supralabials are dark in color; the lower labials are margined

with black, the posterior two or three being somewhat darker. The postoccipital light band is interrupted medially. The under side of the tail is darkened; the dorsal coloration of the tail is somewhat lineal. (Specimen No. 5,417.)

Second: The La Quemada group corresponds most closely to Ruthven's third group; however, the black pigment is mostly confined to the spaces between the scales, seldom invading more than the edges of a few scales between the dorsal and lateral stripes. The dorsal stripe varies in width from one and two half rows to seven and two half rows and is not sharply in contrast with the general body color. This latter is usually a light greenish-gray. The supralabials are dark margined but only slightly darker than the infralabials of which only the ninth has a dark posterior border. The postoccipital transverse line is absent.

Third: The Chapala specimens are most nearly like Ruthven's second group. They are of great interest because they demonstrate very conclusively that a great variation in color pattern obtains between the adult and the offspring.

The adult is a uniform olivaceous, the edges of the scales being considerably darker than the region towards the keels. The dorsal stripe is faintly evident anteriorly, while the lateral stripe is more nearly normal but not as sharply defined as in some of the other groups. There is no evidence of a series of lateral blotches. The supralabials are somewhat darker than the infralabials, which are yellow and margined posteriorly. A postoccipital line is absent. (Specimen No. 4,887.)

The young of this group have a very well-defined dorsal light line one and two half rows in width, with two series of lateral spots between it and the lateral line; below the lateral line is the series of spots noted in the first and second groups. The supralabials are yellow and margined posteriorly, while the infralabials are entirely yellow with the exception of the ninth which has a dark posterior margin; the tenth infralabial, in all specimens, tends to be more or less predominately of the body color. The postoccipital transverse line is well defined. (Specimen No. 4,900.)

Fourth: The group from the vicinities of Mexico City and Puebla have the dorsal and lateral light lines in the usual position and well defined. The more dorsal series of dark blotches contact the narrow black stripe bordering the dorsal stripe; the lateral series of spots does not come in contact with the dorsal series. The spots of the series below the lateral line involve more scales than in the other groups but otherwise they are in the same relative position. The postoccipital line is present; the supralabials are yellow and provided with dark margins, the yellow of the sixth supralabial extending as a band across the entire inferior postocular and ending on the anterior margins of the superior postoculars. The lower labials are yellow and slightly margined, the ninth more so.

The greatest variation shown by the species *Thamnophis macrostemma* Kennicott is the reduction in the total number of ventral scales toward the southern part of its range and the very marked sexual dimorphism of this same character. The presence of four groups which are sharply differentiated geographically by color pattern alone would seem to indicate some form of differentiation.

In conclusion I wish to express my gratitude to Dr. E. H. Taylor, of the Department of Zoölogy, University of Kansas, for his able advice and guidance, and for the loan of the excellent series of specimens from the EHT-HMS collection.

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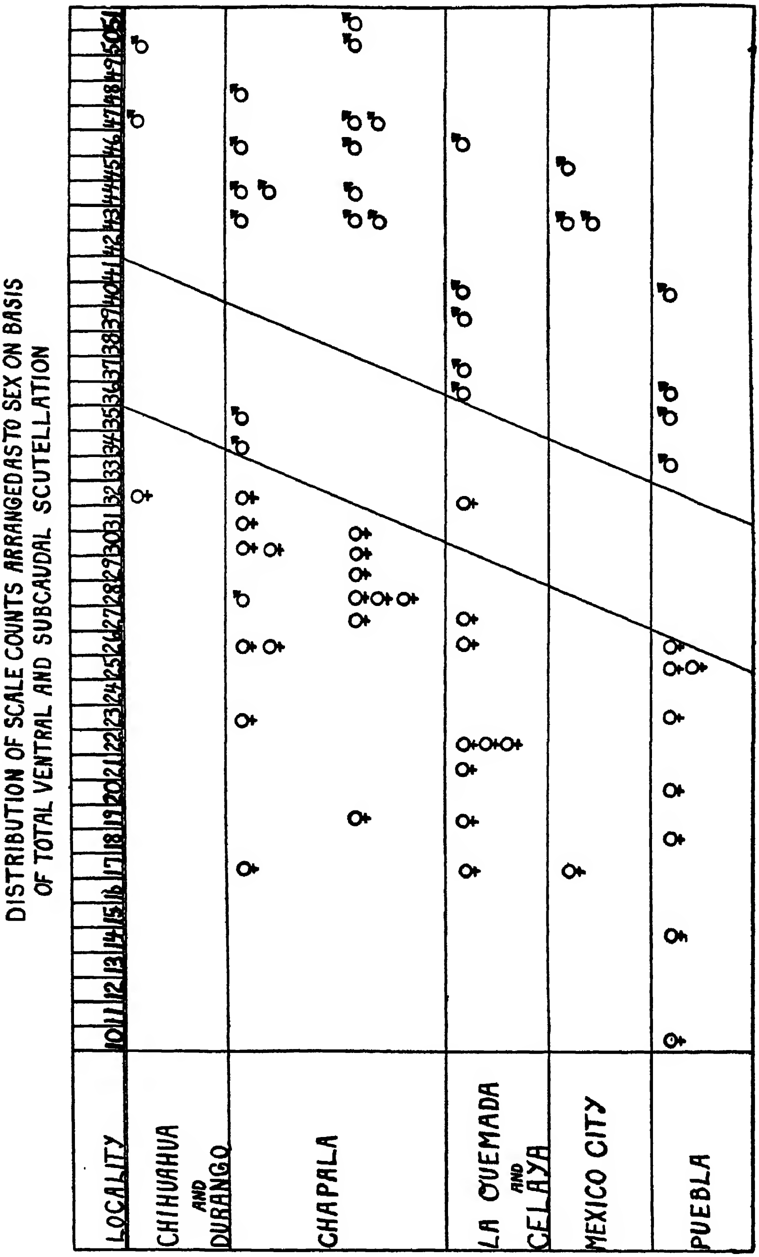
PLATE I



The diagonal lines show the sexual dimorphism to average about six vertebrae, and graphically illustrates the progressive reduction in the total ventral scutellation towards the south.

A Study in Jackrabbit Shifts in Range in Western Kansas

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There are two species of jackrabbits found in western Kansas, the whitetail, *Lepus townsendii campanius* Hollister, and the blacktail, *Lepus californicus melanotis* (Mearns). The blacktail is a southern species and the whitetail is a northern species. Their respective ranges are distinct, but adjacent. The boundary line between their ranges overlaps as little as could be expected with no actual physical barrier between them.

It has been evident to observers for many years that there has been a shift in range of these two species in western Kansas. What has been the extent of this shift in population? Why has it occurred? In an attempt to answer these questions, especially the first one, a study has been made of the history of the two jackrabbit species as they have been observed by early settlers and others over a period of sixty-five years.

Data were gathered from fifty-four western Kansas counties by examination of county bounty records, historical papers and by questioning early settlers. County bounty records were used only as verifying evidence to ascertain relative numbers. Several historical papers were examined for information of early jackrabbit population. Information from early settlers was obtained by personal interviews and from 200 returns from 375 printed questionnaires sent out. The great bulk of the information was obtained by means of these questionnaires.

In the questionnaire, the following general questions were asked: When did you come to Kansas? Where did you locate? The following questions pertaining to the two species of jackrabbits were asked: Were these animals present when you came? How do the present numbers compare with the early days? If they have come into your part of the state since you came, when did you first see them? Are they present now? If not, when did they disappear?

The reliability of the information obtained from early settlers was thoroughly tested in two counties (Ellsworth and Ness) by comparing the reports of all individuals in those counties with one another and with all other available sources, such as bounty records and historical papers. A reasonable degree of reliability was found.

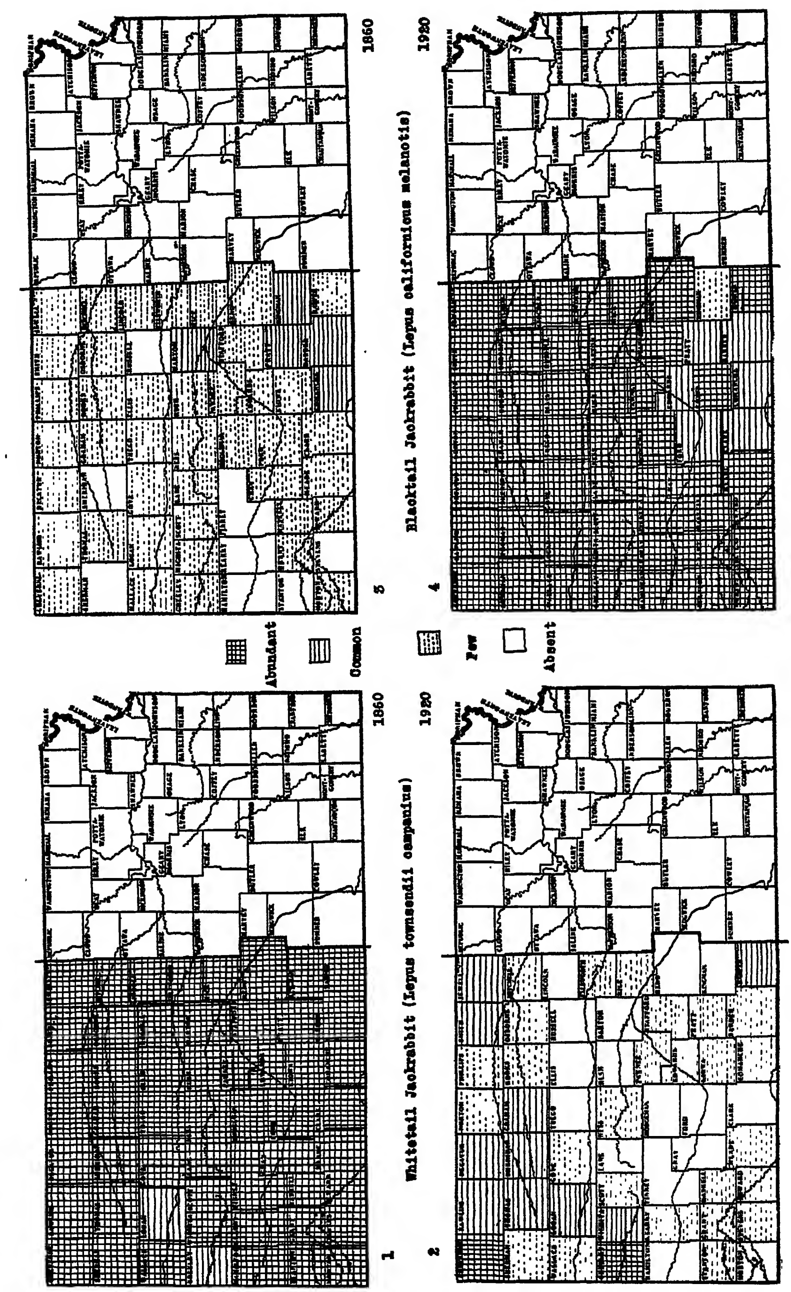
The tabulation of results (Chart 1 and 2) gives rather a graphic picture of the shift which has occurred. It will be seen that, beginning in about 1875, the whitetail began to show a definite decrease in numbers, (Chart 1). This decrease began in the southern counties and moved northward, until by 1900 the whitetails were scarce in most of the counties. They continued rare until recent years when a slight shift back into the state from the north and west is shown. The blacktails began to shift into this area in 1865, and by 1890 were numerous (Chart 2). This increase began in the southern counties and moved steadily northward. The shifts in range were extended until the extremes in jackrabbit population were reached for each species. The maximum

Trans. Kansas Acad. Science, Vol. 42, 1939.

population shown for the whitetails is in 1860 (Fig. 1), while the minimum is shown in 1920 (Fig. 2). For the blacktails the minimum is shown in 1860 (Fig. 3), while the maximum is shown in 1920 (Fig. 4). Of course, it is well known that animal populations fluctuate locally and temporarily, but that is a separate phenomenon from the one here studied. For example, the blacktails reached a maximum in 1934 in some areas.

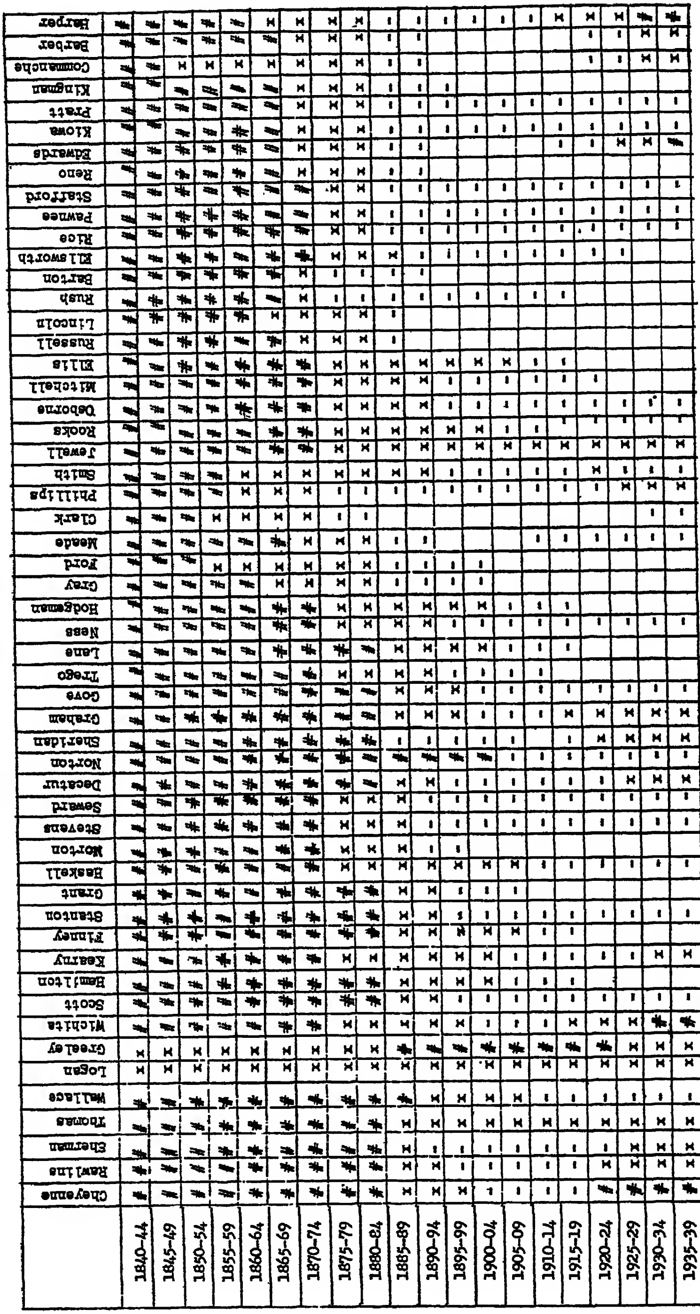
The causes for the shift in range of the two species were not definitely ascertained. Some of the suggestions made by the early settlers of this region are indicated by the following: Climatic changes, human intrusion, and relative numbers of predatory animals. It would be of great biologic and economic value to study further the reasons for this shift in range of the two species of jackrabbits.

In summary, a definite shift in jackrabbit population in western Kansas is found, and during the sixty-five years covered by this study the two species of jackrabbits have not occupied the same range.



MAPS OF KANSAS SHOWING DISTRIBUTION OF TWO SPECIES OF JACKRABBITS

Shift of Whitetail Jackrabbits



\# Abundant
\- Few
x Common
Absent (no marking)

Chart 1.

SHIFT OF BLACKTAIL JACKABBITS

	1840-44	1845-49	1850-54	1855-59	1860-64	1865-69	1870-74	1875-79	1880-84	1885-89	1890-94	1895-99	1900-04	1905-09	1910-14	1915-19	1920-24	1925-29	1930-34	1935-39
Cheyenne	-	-	-	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	x	x
Rawlins	-	-	-	-	-	-	-	-	#	#	#	#	#	#	#	#	#	-	-	-
Sherman								-	-	-	#	#	#	#	#	#	#	x	x	x
Thomas	-	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	#	#
Wallace	-	-	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	x	x	x
Logan	-	-	-	-	-	-	-	x	x	#	#	#	#	#	#	#	#	x	x	x
Greeley	-	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	x	x	x
Wichita			-	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	x	x
Scott					-	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#
Hamilton							-	-	-	-	-	-	x	x	#	#	#	#	#	#
Kearny							-	-	-	-	x	#	#	#	#	#	#	#	#	#
Finney											-	-	-	x	x	#	#	#	x	x
Stanton						-	-	-	-	x	x	x	x	#	#	#	#	#	x	x
Grant	-	-	-	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	#	#
Haskell	-	-	-	-	-	-	-	-	x	x	x	x	x	x	#	#	#	#	#	#
Morton	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	x	x	x
Stevens							-	-	-	-	x	x	#	#	#	#	#	x	x	x
Seward	-	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	x	x	x
Decatur	-	-	-	-	-	x	x	-	x	x	x	#	#	#	#	#	#	x	-	-
Norton	-	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	x	x	x
Sheridan									-	-	x	#	#	#	#	#	#	x	x	x
Graham	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	#	#	x	x	x
Gove	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	#	#	#	#	#
Trego	-	-	-	-	-	x	x	x	x	x	#	#	#	#	#	#	#	#	#	#
Lane	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	#	#	#	#
Ness	-	-	-	-	-	-	-	-	-	-	x	x	#	#	#	#	#	-	-	-
Hodgeman	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	#	#	#	#	#
Gray	-	-	-	-	-	x	x	#	#	#	#	#	#	#	#	#	#	x	x	x
Ford	-	-	-	-	-	x	x	x	x	x	x	x	x	x	x	x	x	-	-	-
Meade	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	#	#	-	-	-
Clark	-	-	-	-	-	-	-	-	x	x	x	x	x	x	x	x	x	x	x	x
Phillips	-	-	-	-	-	-	-	-	x	x	#	#	#	#	#	#	#	x	x	x
Smith	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	x	x	#
Jewell	-	-	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	x	x	x
Rooks	-	-	-	-	-	-	-	x	x	x	x	x	#	#	#	#	#	#	#	#
Osborne	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	x	x	x
Mitchell	-	-	-	-	-	-	-	x	x	#	#	#	#	#	#	#	#	#	#	#
Ellis	-	-	-	-	-	-	x	x	x	x	x	x	#	#	#	#	#	x	x	x
Russell						-	-	x	x	x	#	#	#	#	#	#	#	x	x	x
Lincoln	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	#	#	x	x
Rush	-	-	-	-	-	-	-	-	#	#	#	#	#	#	#	#	#	#	-	-
Barton	x	x	x	x	x	x	x	x	x	x	x	#	#	#	#	#	#	#	x	x
Ellsworth	-	-	-	-	-	-	x	x	x	x	x	#	#	#	#	#	#	x	x	x
Rice	-	-	-	-	-	-	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Pawnee	-	-	-	-	-	-	-	x	x	x	#	#	#	#	#	#	#	x	x	x
Stafford	-	-	-	-	-	-	-	x	x	x	x	#	#	#	#	#	#	x	x	x
Reno	-	-	-	-	-	-	x	x	x	x	x	#	#	#	#	#	#	x	x	x
Edwards	-	-	-	-	-	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Kiowa	-	-	-	-	-	-	x	x	x	x	x	#	#	#	#	#	#	#	#	#
Pratt	-	x	x	x	x	x	x	x	x	x	x	#	#	#	x	x	x	x	x	x
Kingman	x	x	x	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	-	-
Commanche	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Barber	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Harper	-	-	-	-	-	-	-	-	-	x	#	#	#	#	#	#	#	#	#	#

\# Abundant x Common
\- Few Absent (no marking)

Chart 2.

Intermediate Hosts of Chicken Tapeworms Found in Kansas [1]

A. A. CASE and J. E. ACKERT, Kansas State College, Manhattan, Kan.

The recent findings of Ackert and Case (1938) on effects of tapeworms on chickens have reëmphasized the importance of these parasites. These authors found that cestode infections of even three weeks' duration affected the blood of the chickens and that infections of eight weeks' duration lowered the hemoglobin and sugar content of the blood, and retarded the growth of the chickens. While fowl taeniasis can be checked momentarily by administering taeniacides no effective control of these parasites can be established without breaking the life cycle at some stage. In order to do this knowledge must be gained of the available intermediate hosts. To determine these, life history studies of various species of fowl cestodes have been conducted recently in several laboratories; notably at the United States Zoölogical Division, Washington, at the Veterinary Academy, Hanover, Germany, and at the Kansas State College of Agriculture and Applied Science, Manhattan.

Whereas, a decade ago, garden slugs, earthworms, and flies were thought to be the principal intermediate hosts of chicken tapeworms, the recent findings have shown that ground beetles (Carabidae) are doubtless the principal means of transmitting the more common chicken tapeworms. It was to make known more generally the newer knowledge of intermediate hosts of fowl tapeworms found in Kansas that this study was undertaken.

NORTH AMERICAN CHICKEN TAPEWORMS

Of ten species of tapeworms found in the United States (Cram, 1928), the following six species have been reported from Kansas:

Raillietina cesticillus (Molin, 1858).
Choanotaenia infundibulum (Bloch, 1779).
Raillietina tetragona (Molin, 1858).
Hymenolepis carioca (Magalhaes, 1898).
Raillietina echinobothrida (Megnin, 1880).
Amoebotaenia sphenoides (Railliet, 1892).

The other four species reported from this country are: *Davainea proglottina* (Davaine), *Diorchis americana* Ransom, *Hymenolepis cantaniana* (Pol.), and *Metroliasthes lucida* (Ransom).

KANSAS FOWL CESTODES AND THEIR INTERMEDIATE HOSTS

Raillietina cesticillus

The fowl cestode that probably is of the most common occurrence in Kansas is the rather large species, *Raillietina cesticillus,* whose habitat is the duodenum. Ferry (1934) reported it from sixty-two percent of the chickens he examined. However, Adams and Geiser (1933) found it in only twelve percent of the chickens they examined in Texas. Although houseflies can prob-

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ably act as secondary hosts (Ackert, 1918; Reid and Ackert, 1937) the most important intermediate hosts are various species of beetles (Coleoptera), especially those of the family Carabidae (ground beetles). Besides several genera of the families Scarabaeidae, Tenebrionidae, and Ostomidae, there are eight genera and twenty-five species of Carabidae which may serve quite readily as intermediate hosts. The beetles most frequently found at Manhattan (Riley county, Kansas) are of these species. In half an hour in midsummer (July) it has been possible to collect 175 Carabidae on the campus of the Kansas State College. The most numerous of these Carabidae are species of the genera *Cratacanthus* and *Amara*. After a morning rain, beetles of these genera may be seen by the hundreds. Species of *Cratacanthus* and *Amara* have been found to be the best intermediate hosts for the cestode, *R. cesticillus* as determined by experimentation. The ease with which mature cysticercoids can be developed in beetles has led to the use of *R. cesticillus* for experimental studies of Ackert and Case, mentioned above, of Ackert and Reid (1937), who demonstrated an age resistance of older chickens to the growth of these cestodes, and of Harwood and Luttermoser (1938), who found that infections of this cestode retarded the growth of chickens.

Intermediate Hosts of R. cesticillus

Coleoptera: Family Cantharidae: **Podabrus modestus* Say; Family Carabidae: *Amara* sp., *Amara basillaris* (Say), *Amara fallax* Lec., *Amara* (*curtonotus*) *laticollis* Lec., *Amara* (*celia*) *muscula* Say., *Amara* (*Percosia*) *obesa* Say., *Anaferonia* (*Pterostuchus*) sp., *Anaferonia constricta* Say., *Anaferonia* near *substriata* (Lec.), *Anisotarsus* sp., *Anisotarsus agilis* (Dej.), *Anisotarsus subvirens* Csy., *Chalenius tomentosus* Say., *Cratacanthus dubius* Beauv., *Harpalus* sp., *Harpalus faunus* Say., **Harpalus herbivagus* Say., *Harpalus pennsylvanicus* DeGeer., *Pterostichus* near *permundus*., *Pterostichus* (*Poecilus*) *chalcites* Say., *Pterostichus* near *constricta*., *Pterostichus* (*Abacidus*) *permundus* Say., *Pterostichus* (*Eumolops*) *torvus* Lec., *Selenophorus* (*pedicularius* DeG.), *Triplectrus rusticus* Say.

Family Ostomidae: **Tenebroides mauritanicus* (L.); Family Scarabaeidae: *Choeridium histeroides* (Web.), *Aphodius granarius* (L.); Family Tenebrionidae: *Tenebrio* sp., *Tribolium confusum* Duval., *Tribolium* sp.

Hymenolepis carioca

Second in the list of tapeworms from Kansas chickens appears to be *Hymenolepis carioca*, a delicate, threadlike cestode which may be present in large numbers (500 or more) in a single bird, according to Ferry (1934). Twiehaus (unpublished) likewise found large infections of this cestode in ailing chickens in Kansas that were sent the Kansas State College Poultry Diseases laboratory in April, 1939. Adams and Geiser found this species to be the most abundant in Texas (37 percent). As to transmission, Cram and Jones (1929) found that various species of Coleoptera may act as intermediate hosts of *H. carioca*. Subsequent studies by Jones indicated that the beetles that could transmit these tapeworms belong to the Scarabaeidae and possibly to the Carabidae.

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* New intermediate hosts of *R. cesticillus* recently announced (abstract) by Case and Ackert (1938) are marked with an asterisk.

INTERMEDIATE HOSTS OF H. CARIOCA

COLEOPTERA: Family Carabidae: *Anisotarsus agilis* (Dej.); Family Scarabaeidae: *Aphodius granarius* (L.), *Choeridium histeroides* (Web.); Family Histeridae: *Carcinops quatuordecimstriata* Steph.

DIPTERA: Family Muscidae: *Stomoxys calcitrans* L.

Raillietina tetragona

The third ranking tapeworm in prevalence in the vicinity of Manhattan appears to be *Raillietina tetragona*. It was third (38 percent) in Ferry's studies in eastern Kansas and second in Texas (Adams and Geiser). This large tapeworm attaches itself to the lower portion of the small intestine and may produce nodules of the intestine which closely resemble lesions of tuberculosis. Horsfall (1938) reported that the common pavement ants *Tetramorium caespitum* (L.) and *Pheidole vinelandica* Forel. could serve as intermediate hosts of *R. tetragona*. Studies upon ants as means of transmitting chicken tapeworms from one host to another are in progress by the writers at the Kansas Experiment Station.

INTERMEDIATE HOSTS OF R. TETRAGONA

HYMENOPTERA: Family Formicidae: *Tetramorium caespitum* (L.), and *Pheidole vinelandica* Forel.

Choanotaenia infundibulum

A fowl cestode that is of very common occurrence in the vicinity of Manhattan, Kan., is *Choanotaenia infundibulum*. Both Ferry (1934) and Adams and Geiser (1933), however, found this species to be the least abundant of the tapeworms they studied. Its habitat is the duodenum.

As to intermediate hosts, Guberlet (1916) found that houseflies (*Musca domestica* L.) are a means of transmitting *Choanotaenia infundibulum* from one chicken to another. Cram (1928), Cram and Jones (1929) and Wetzel (1936) obtained evidence that pointed to beetles as being important intermediate hosts of this tapeworm. Horsfall and Jones (1937) added six species of beetles and two of grasshoppers as new intermediate hosts of *C. infundibulum*.

Further evidence that houseflies may serve as intermediate hosts of *C. infundibulum* was presented by Wetzel (1936), who reported that only twenty percent of the houseflies in his experiments developed cysticercoids and that the number of cysticercoids was small. Reid and Ackert (1937) found a natural infection of ninety-one cysticercoids in a housefly at Manhattan, Kan. Even if only twenty percent of the houseflies developed cysticercoids, the quantities of flies around poultry yards at certain times of the year could easily supply the cysticercoids necessary to produce the heavy tapeworm infections (75 percent) in the naturally infected chickens in an experiment by Reid and Ackert (1937) at Manhattan, Kan.

INTERMEDIATE HOSTS OF C. INFUNDIBULUM

COLEOPTERA: Family Carabidae: **Amara fallax* Lec., **Anaferonia constricta* Say, *Cratacanthus dubius* Beauv., *Stenocellus debilipes* (Say), *Stenolophus conjunctus* (Say); Family Ostomidae: **Tenebroides mauritanicus* (L.); Family

* New intermediate hosts of *Choanotaenia infundibulum* (Block.) marked with an asterisk. Indebtedness is acknowledged to H. R. Bryson, L. L. Buchanan, and to W. S. Fisher for aid in identifying these beetles.

Scarabaeidae: *Aphodius granarius* (L.), *Aphodius* sp., *Geotrupes sylvaticus* Panz.; Family Staphylinidae: *Apocellus sphaericollis* (Say); Family Tenebrionidae: *Alphitophagus bifasciatus* (Say).

DIPTERA: Family Muscidae: *Musca domestica* (L.).

ORTHOPTERA: Family Locustidae (Acrididae): *Dicromorpha viridis* (Scudder); *Melanoplus femur-rubrum* (DeGeer).

Raillietina echinobothrida

Among the less abundant fowl tapeworms in Kansas is the largest species *Raillietina echinobothrida*. This worm resembles *R. tetragona* closely and is distinguished from it with difficulty. *R. echinobothrida* also attaches itself in the posterior part of the small intestine, and has about the same effects upon the host as *R. tetragona*. Ferry (1934) found this cestode in four percent of the chickens examined in Douglas county, Kansas, and Adams and Geiser found it in twelve percent of the fowls examined in Texas. According to Horsfall (1938), the common pavement ant, *Tetramorium caespitum* may serve as an intermediate host of *R. echinobothrida*. An interesting observation was made by Horsfall (1938), who stated, "The first clue to the intermediate hosts of *R. echinobothrida* and *R. tetragona* was discovered while the writer had under observation in the experimental yard several fecal samples containing *R. echinobothrida* proglottids. An ant carried one of these segments from the feces to an entrance to a nest and disappeared with it. Ants were then examined from this yard and all were found to be negative until August 16, 1935, at which time three *T. caespitum* were dissected and found to contain four cysticercoids the scoleces of which resembled those of *R. echinobothrida*." Larvae of *R. echinobothrida* in the naturally infected ant *Tetramorium semilaeve*, from Marseilles, France, were reported by Joyeux and Baer (1937).

INTERMEDIATE HOSTS OF R. ECHINOBOTHRIDA

HYMENOPTERA: Family Formicidae: *Tetramorium caespitum* (L.), *T. semilaeve* and *Pheidole vinelandica* Forel.

Amoebotaenia sphenoides

A tapeworm present in four percent of the Douglas county, Kansas, chickens examined by Ferry (1934) was the small wedge-shaped *Amoebotaenia sphenoides*. This cestode, which apparently is of rare occurrence in the United States, was reported from eight percent of the chickens examined by Adams and Geiser (1933) in Dallas county, Texas. The intermediate hosts are annelids according to Mönnig (1927) who, in fourteen days, grew the cysticercoids in earthworms [*Ocnerodrilus* (*Ilyogenia*) *africanus*, Beddard]. Four weeks were required for the cysticercoids to develop into adult tapeworms in chickens. Grassi and Rovelli (1889) and Meggit (1916) undoubtedly secured cysticercoids of this tapeworm by feeding the oncospheres to earthworms (*Allolobophora foetida* Eis.).

INTERMEDIATE HOSTS OF A. SPHENOIDES

OLIGOCHAETA: Family Lumbricidae: *Allolobophora foetida* (Eisen), and *Ocnerodrilus* (*Ilyogenia*) *africanus* Beddard.

Davainea proglottina (Not reported from Kansas)

A small tapeworm (four to nine segments) that is found in many countries, but has not been reported from Kansas is *Davainea proglottina*. Because of its minute size it may have been overlooked. Various writers have described it, and Levine (1938) has studied phases of its biology. Wetzel (1936) reported that the most important intermediate host of *D. proglottina* in Germany is the garden slug *Agriolimax agrestis*. Mönnig (1938) lists as intermediate hosts of *D. proglottina* the slugs: *Limax cinerus, Arion* sp., *Cepoa* sp., and *Agriolimax* sp., and the snail *Physa heterostropha* (Say). Of these genera, *Agriolomax* and *Physa* are found in Kansas; so that it is possible that *D. proglottina*, for which these gastropods may be intermediate hosts, is also present in Kansas, especially in the eastern and moister part of the state.

INTERMEDIATE HOSTS OF D. PROGLOTTINA

PULMONATA: Family Arionidae: *Arion* sp.; Family Limacidae: *Agriolimax* sp., *Cepoa* sp., *Limax cinerus;* Family Physidae: *Physa heterostropha* (Say).

SUMMARY

1. Of ten species of fowl tapeworms reported from the United States, the following six species have been found in chickens in Kansas: *Raillietina cesticillus* (Molin, 1858), *Choanotaenia infundibulum* (Bloch, 1779), *Raillietina tetragona* (Molin, 1858), *Hymenolepis carioca* (Magalhaes, 1898), *Raillietina echinobothrida* (Megnin, 1880), and *Amoebotaenia sphenoides* (Railliet, 1892).

2. The three following species of beetles are here reported for the first time as intermediate hosts of the chicken cestode *Choanataenia infundibulum: Amara fallax* Lec., *Anaferonia constricta* Say, and *Tenebroides mauritanicus* (L.).

3. The known species of intermediate hosts of the tapeworms found in Kansas chickens consist of beetles, flies, ants, slugs, snails, and earthworms. They are given according to order, family, and genera for the respective tapeworms.

4. Most numerous of these intermediate hosts are ground beetles (Carabidae) of which eight genera and twenty-five species have been identified as intermediate hosts of chicken cestodes.

Altogether nineteen genera and twenty-nine species of beetles may act as intermediate hosts of one or more of the important chicken tapeworms found in Kansas.

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Pigment Production in the Guinea Pig

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GENETIC ASPECTS

The skin and hair of fetal and adult guinea pigs of known genetic composition were studied, with special attention to the effects of the following factors as described by Bogart and Ibsen (1937):

The extension series: E, e^p and e.

Black and chocolate: B and b.

The intensity series C, c^d, c^r, and c^a.

The earliest stages of development of hair and formation of pigment were observed in fetuses of 43 and 44 days copulation age. At this age no difference could be recognized between black, chocolate, and red pigment granules. It is likely, however, that these types are distinct from the beginning.

In older fetuses and in adult animals four types of granules were seen in the hair: black, chocolate, red, and colorless. Diffuse reddish pigment was seen only in the cortex of fully formed black, chocolate, and red hairs. It was found only in close association with one of these three types of granular pigment.

The extension factor E determines the presence of black or chocolate granules in the hair except in c^a animals. Its recessive allelomorph e in the homozygote determines the presence of red granules in C and c^d hairs and of colorless granules in c^r and c^1 hairs. We found no black or chocolate granules in any ee hair, whether red or white, in a spot, or on a self animal.

In the presence of ee:

C determines the presence of a large amount of red granules.

c^d determines the presence of a few paler red granules.

c^a and c^r determine the absence of red granules.

No pigmentation of any sort appears in c^r and c^a white hairs, although both contain colorless granules.

Diffuse red pigment is not determined primarily by the genetic composition of the animal. Rather, it appears in the cortex of the hair in varying amounts as a consequence of the presence there of some type of granular pigment. Part of the difference between the types of granules seems to lie in their relation to the diffuse type of pigment. This close relation between granular and diffuse pigment is parallel to the description of the C series as given by Bogart and Ibsen, in which the red coloring has no factor of its own, but is included with the dark granular pigment.

It is possible that the factors B and b have some degree of effect on red granules comparable to their effect in producing two kinds of dark granules.

The brownish color of newborn cherry red animals is due to a concentration of red pigment rather than to the presence of black or chocolate granules.

Treatment with fifteen percent sodium hydroxide solution indicates the presence of a dilute form of red diffuse pigment in white hairs. We have not observed this in our microscopic examinations. With this exception the results of the two methods of examination agree.

CYTOLOGICAL ASPECTS

Granular pigment is seen first in the cytoplasm of certain large cells in the basal layer of the epidermis and in the tip of the developing hair follicle. In some animals it appears later in similar cells in the follicle sheath. We have not found it in the hair papilla nor in the dermis. The pigment cells are ectodermal in origin. They are seen first in fetuses of 43 days copulation age.

The pigment bearing cells are larger than the ordinary cells of the dermis and epidermis, and usually are irregularly star-shaped, with long pseudopodia-like processes. The pigment granules may be scattered throughout the cytoplasm or concentrated in one or several rounded masses near the nucleus. These pigment cells often exhibit mitotic figures. The pigment granules are divided approximately equally between the daughter cells.

Pigment cells of another type appear in the skin of older fetuses and adult animals. These cells are small and rounded and make up the greater part of the epidermis. Pigment granules in them are usually concentrated in a caplike mass at the peripheral end of the cell.

Only the large branching pigment cells occur in the hair follicle. In the developing hair they give rise to the spindle-shaped cornified cells of the cortex and the shrunken irregular cells of the medulla.

Pigment granules are present between the cells of the basal layers of the skin and hair.

In younger fetuses red, black, and chocolate granules look alike. Colorless granules are present in c^r and c^a white hairs. The time and the place of appearance are the same for all the types of granules.

Diffuse reddish pigment was seen only in the cortical layer of the hair. It seems to be a product of the granular pigment.

The pigment granules are not produced in the nucleus, nor are they formed directly from nuclear material.

Some Effects on Guinea Pigs of Feeding Vitamin C Intermittently [1]

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INTRODUCTION

Resorption of bone at the bases of the cheek teeth and along the edge of the alveolar area has been reported in guinea pigs as a result of feeding a standard vitamin C-free diet without supplement, or with a minimum amount of supplement. (4)

PURPOSE

The purpose of this experiment was to determine whether there would be recovery from the above-mentioned disorder; and, if so, what would be the nature of it if the guinea pigs were given a vitamin C supplement after being deprived of it for a sufficient length of time to produce scurvy.

REVIEW OF LITERATURE

Decalcification of the teeth, alveolar resorption, dental caries, and irregularities of teeth have been reported in guinea pigs as a result of scorbutic feeding (*6*), (*7*), and (*1*).

The fact that there is an improved condition in the guinea pig after changing from a scorbutic diet to a normal diet has been noted. One author states that: "Almost as if by magic a change occurs when vitamin C-containing foods are administered in sufficient amounts. A comparison between the structure of the tooth which had been extracted at the height of the scorbutic stage, with the tooth permitted to remain and develop under the reëstablished normal feeding, shows that a healing process has begun" (*9*).

A "recovery" method has been devised to measure the amount of vitamin C in a food. It is based on the resumption in the growth rate of an animal which had been on a scorbutic diet (*5*).

Howe reported that recalcification occurred on improving the diet (*6*).

Fish and Harris discussed the cure of scurvy and the effects of intermittent attacks of scurvy on the tooth structure in guinea pigs (*3*).

MATERIALS AND METHODS

This experiment was based on observations of forty-seven animals of different ages and sex. The animals were fed a standard vitamin C-free diet (*12*) (*8*), found to be adequate in all other respects for growth and reproduction, except for the lack of this vitamin. The supplements used were ascorbic acid and greens. The ascorbic acid was crystalline vitamin C sold as "Cebione" by Merck in the form of 10 mg. tablets. One tablet was assumed to be the equivalent of 20 ml. of orange juice at a vitamin C content of 0.5 mg. per ml. (*10*). It was fed at the level of 3 ml./300 gm. body weight (*1*).

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Contribution No. 87, Department of Home Economics; and No. 204, Department of Zoölogy, Kansas Agricultural Experiment Station, Manhattan, Kan.

In the beginning all the animals received the vitamin C-free diet plus greens, for at least one week, until they became accustomed to their new surroundings. They were then divided into four groups which were fed as follows: (1) Continuation of the vitamin C-free diet, plus greens; (2) vitamin C-free diet, plus ascorbic acid; the supplement was removed from the diet then added again; (3) a continuation of group 2, except that the ascorbic acid supplement was removed for a period of time and then added a second time; and (4) vitamin C-free diet without first giving the animals the ascorbic acid supplement which was later added to the diet.

High-grade filter paper, which was kept in the cages at all times, furnished roughage. Some of the animals died and others were killed at definite times. All jaws were preserved in ninety-five percent alcohol.

OBSERVATIONS

In the first group there were twelve animals which received the vitamin C-free diet, plus greens, for periods of 28 to 240 days. At the beginning of the experiment the animals ranged in weight from 205 to 502 grams. Two were male animals. All were killed except one, which died of a pregnancy disorder. All of the animals which received greens were in good physical condition and made a normal gain in weight. Judging from the criterion set by Harman, Kramer, and Kirgis, their jaw bones and cheek teeth were sound. (4) The incisors were normal, with the exception that the bases of the upper ones of nine of the animals were slightly dark.

In the second group there were thirteen female animals which ranged in weight from 192 to 262 grams at the beginning of the experiment. Ten animals in this group received the vitamin C-free diet, plus ascorbic acid, for seven days. Then the supplement was removed for sixteen days. All the animals died after they had received the supplement again for periods which ranged from one to eighty-nine days. All of the animals showed characteristics of scurvy when they were changed to the supplemented diet and at the time of death. It was interesting to note that there were four animals which lived for periods from eleven to eighty-nine days after they received the supplement again. Each of these animals showed a gain in weight prior to the final decrease in weight before death. Each had extremely long incisors which were discolored and curled to such an extent that they protruded from the mouth causing the animal to salivate continually. This condition became progressively worse before the animals died. The other three animals in this group received the ascorbic acid supplement continuously for 135 days until their weights ranged from 693 to 792 grams. The supplement was removed for twenty days after which slight characteristics of scurvy began to appear. Then the supplement was restored to the diet and the animals were allowed to live for fifty days. They had made a good gain in weight and appeared in good physical condition. The jaw bones, cheek teeth, and incisors were normal.

The third group was composed of six animals which ranged in weight from 204 to 299 grams at the beginning of the experiment. They received ascorbic acid supplement for seven days, were without it for sixteen days, then received it again for 112 days. They appeared normal in all outward respects. The supplement was removed a second time for twenty days, then restored for

fifty-four days when the animals were killed. The gain in weight, the jaw bones, the cheek teeth, and the incisors of these animals were normal. One, which had made a less marked gain, was found to have a jawbone in poorer condition, and the incisors had been rather dark and long.

The ten animals in the second group, which died after their first attack of scurvy, may be contrasted with this third group of six animals. They were approximately the same size as the animals in the second group and received identical treatment, yet these animals all recovered from the first attack of scurvy. They were then subjected to another attack of scurvy for twenty days, and again they recovered.

The fourth group was composed of sixteen animals which received greens instead of ascorbic acid before they were subjected to the scurvy-producing diet. Three male animals in this group received greens for sixty-one days. Their weights ranged from 563 to 616 grams when the supplement was removed for twenty days. These animals made a good gain in weight and had normal jaws, cheek teeth, and incisors after they had received ascorbic acid for fifty days. They are compared to three female animals in group 2 which received ascorbic acid supplement instead of greens until they were approximately the same size. Then both groups were without vitamin C for the same length of time and they were put back on ascorbic acid for the same length of time. Both groups made a good gain in weight and possessed normal jaws and cheek teeth.

The other twelve animals in this group were without supplement for twenty-eight days. Five in this group were males, three of which were born in our own colony from mothers which had received greens. These twelve animals received greens for periods of twenty-three, thirty-eight, forty-five, and 122 days before this source of vitamin C was removed. Their weights at the time the supplement was removed ranged from 356 to 702 gms. Ten of these animals died after they had received the ascorbic acid supplement for periods from one to thirty days. Only the upper incisors were affected, and in some cases both upper and lower incisors appeared normal. The two animals which had lived for twenty-seven and thirty days had the previously described abnormal growth of their incisors. All of the jaws and the cheek teeth were in very poor condition. The two animals which made a good gain in weight received supplement for thirty-five days before they were killed. Their jaws, cheek teeth, and incisors were normal. We noted that of two male animals which were born from the same mother and which received exactly the same treatment, one recovered and the other succumbed to an attack of scurvy.

DISCUSSION

In the data reported here, the results of intermittent feeding of vitamin C supplement to a vitamin C-free diet have been observed. Further proof is given that for normal growth and best physiological condition, a liberal amount of vitamin C should be included in the diet regularly as there is not much storage, regardless of age or sex. (*4*), (*2*), (*11*). It is also apparent that animals can be without vitamin C in the diet for a short time and still live, as indicated in the "recovery method" described by Harris, Mills, and Inns, and the intermittent attacks of scurvy that Fish and Harris produced in their animals.

Howe pictured the incisors with the enamel marked by alternating normal and deficient diets. We were unable to detect any such definite markings. Fish and Harris state that growth of a cheek tooth is about one-fourth as fast during a period of avitamosis C as compared to growth under normal conditions. Eddy and Dalldorf state that the normal rate of growth of guinea pig incisors is 0.7 to 0.8 mm. per day. Even if we assume that the growth of the incisors would be retarded to the same extent as the cheek teeth under scurvy conditions, it does not seem possible that more than one attack of scurvy could leave its mark on the incisors as they were growing out. If the incisors were discolored at all, the upper ones were discolored first and to a greater degree in every case. The cause of the abnormal growth of the incisors of those animals that lived for several days after they were put back on a supplemented diet is not known. It is possible that the death of the animals was finally due to the fact that the long, curled incisors made eating very difficult.

Even though there is a chance for recovery after a pronounced degree of scurvy, there is probably a greater chance for death. This was indicated by Harris, Mills, and Inns in their statement that in the use of the "recovery method," one should not use any animals that had declined too far or there was failure to respond. It is difficult to detect the point in experimental scurvy where there will still be a response to a supplemented diet.

Since those animals which were on the supplemented diet for long periods of time had a normal growth rate and the jaws were in good condition, it is reasonable to assume that the level of ascorbic acid supplement we used was sufficient for normal growth. However, it is probable that the intake of vitamin C is, as Sherman put it, "one of those factors from which there is increasing benefit from an increasing liberal intake."

The individual difference between animals were apparent in this experiment. Some seem to have good jaws and resume a normal rate of growth upon receiving the supplement, while in others there is a question of full recovery although similar animals had been treated alike.

CONCLUSIONS

1. Guinea pigs have the best chance for normal growth and good physiological conditions if vitamin C is supplied liberally and regularly.
2. It is possible for them to live without vitamin C for a short time.
3. The degree of resistance to an attack of scurvy is an individual factor.
4. Although there is a chance for recovery from a pronounced case of scurvy produced by a limited amount of vitamin C, there is probably a greater chance for death.
5. In some cases the animals seem to recover fully; in others there is a question of full recovery although the animals continue to live.

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Studies in Human Biology

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It is a well-known fact that almost all forms of wild mammals and birds have periods of reproduction coincident with certain seasons of the year, and that their domesticated relatives, or descendents, do not adhere so rigidly to these seasons. With this in mind, it becomes an interesting problem as to whether or not man in his present state of civilization, that may be somewhat comparable to domestication, shows any evidence of seasonal reproduction. At first thought it might be concluded that no seasonal periodicity could occur because reproductive cycles in man recur at frequent and regular intervals throughout the year. From studies on certain monkeys and anthropoid apes, however, it is a well-established fact that in many of the cycles fertilization does not follow mating, and, in fact, no functional egg cells are produced. It is, perhaps, not too much to expect that a similar condition could exist in man.

In order to study this problem, information was secured from college students regarding themselves and their immediate families. This information was obtained from students of two colleges to see what the general conditions were, and especially to ascertain if the two groups were alike. The year of birth and month of birth for both parents and children were recorded from students attending the Louisiana State Normal College from 1932 to 1934 and from Kansas State College in 1938 and 1939. (Birth dates of more than 10,000 Kansas students were also included in graph 1 taken from enrollment cards, 1926, 1930, and 1934.) Graph 1 gives the distribution of births by months for both Louisiana and Kansas students.

Although there is not a great difference in distribution for the different months, it was noted, repeatedly, in compiling the data that any group of a few hundred followed very closely the distribution for the total of more than 16,000. From this study it was evident that September, or adjacent months, was the time of most frequent births. December and January showed consistent minor peaks in the curve, with springtime as the low part of the curve. Since the data were so consistent, it is believed this curve is a fair index to the distribution of births within the year. There appears to be some evidence for a seasonal cycle of births in human beings. No marked difference between the Louisiana and Kansas groups is evident.

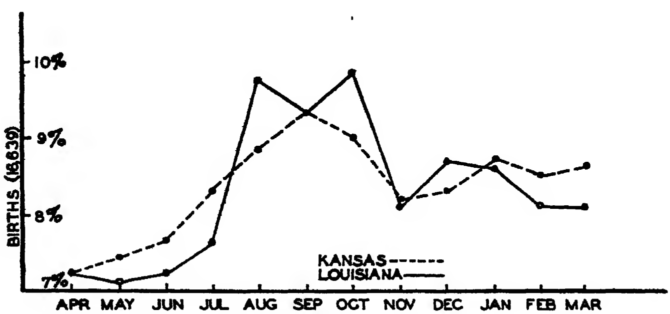
In addition to the distribution of births by months, several other studies were made from the information obtained from students. The size of family was recorded, as shown in graph 2, which includes information on approximately 700 families from each state. This, of course, includes only families in which one or more children were attending college, and does not include those families with no children. It may readily be seen that larger families are more prevalent in Louisiana than in Kansas. In nearly one-fourth of the Kansas families there are three children, but with a very rapid drop in the number of families larger than this. It is interesting to note that only two and one-half percent difference exists between the two groups of one-child families.

Trans. Kansas Acad. Science, Vol. 42, 1939.

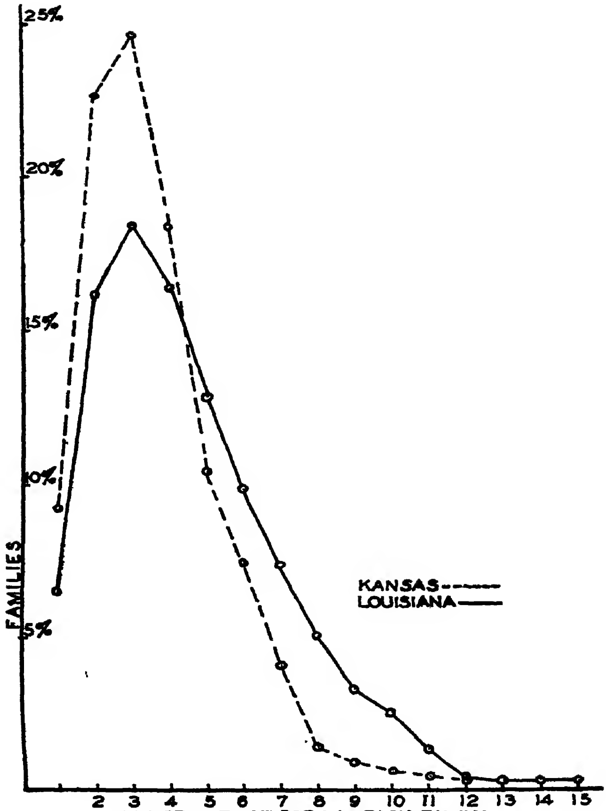
The interval between births was recorded to find a most striking similarity between the two groups (graph 3). Two years is the most common interval. The two-year interval is approximately twice as common as the three-year. The one- and four-year intervals are approximately equal, and about one-half as prevalent as the three-year. In this study it was revealed that in approximately one-half the families, the interval before the birth of the last child was longer than any other interval in the family. This was true in both the Kansas and Louisiana groups. The reason for this extended interval can only be guessed at, but it is possible the answer would reveal facts of considerable biological significance.

One of the greatest differences between the two groups was in the ages of the mothers at their first birth (graph 4). Almost twice as many Louisiana as Kansas mothers had given birth to at least one child by the age of twenty-two years. The largest number of Louisiana mothers were twenty-one years of age at their first birth, whereas the largest number of Kansas mothers were twenty-four.

The ages of the mothers at the time of their last birth shows no particular differences in the two groups (graph 5). The curves are somewhat irregular and do not make abrupt peaks. The most common age at last birth is near thirty-four years. Although it was not studied critically, there seemed to be good evidence that in medium to large families the mother was fairly young (middle thirties) at the time of last birth. In those families the mother was rather young at the time of her first birth and successive births were at fairly regular intervals. In the medium to small families the births were at infrequent and irregular intervals, and the last one frequently occurred when the mother was in the "late thirties" or "forties."



GRAPH 1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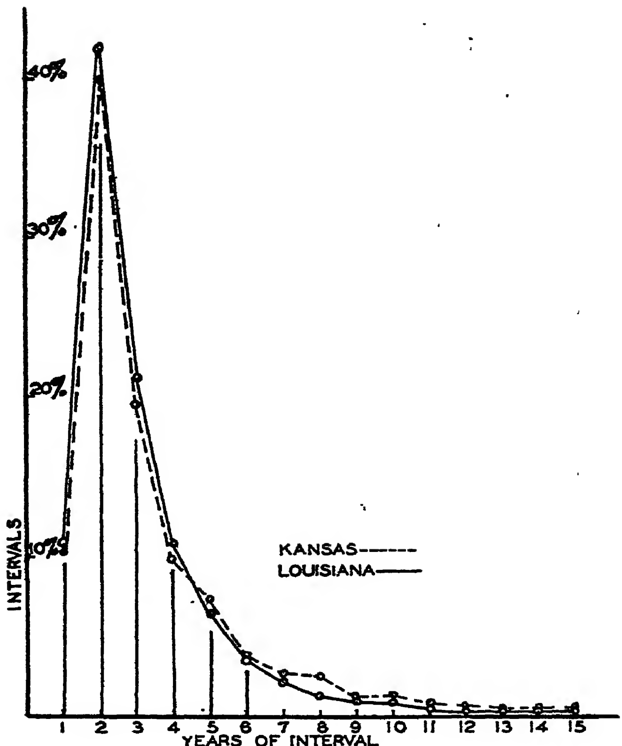
20%
15%
10%
5%
FAMILIES
KANSAS
LOUISIANA
2 3 4 5 6 7 8 9 10 11 12 13 14 15
NUMBER OF CHILDREN IN EACH FAMILY

GRAPH 2


40%
30%
20%
10%
INTERVALS
KANSAS
LOUISIANA
1
2
3
4
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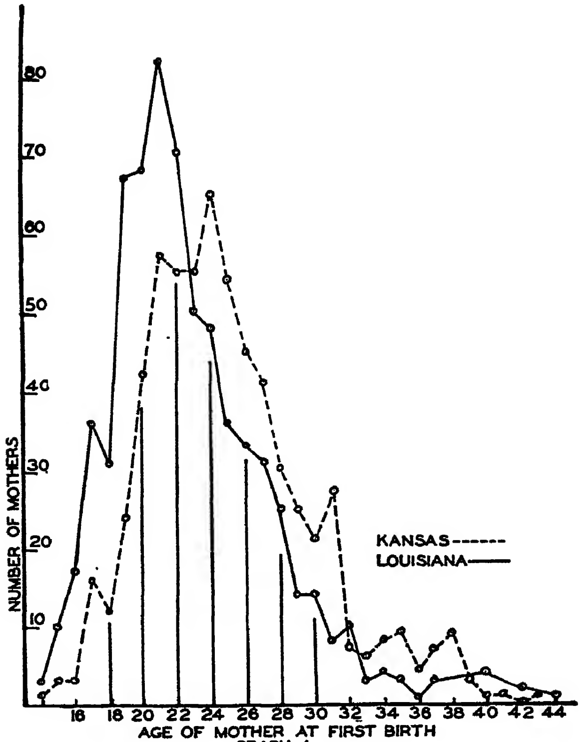
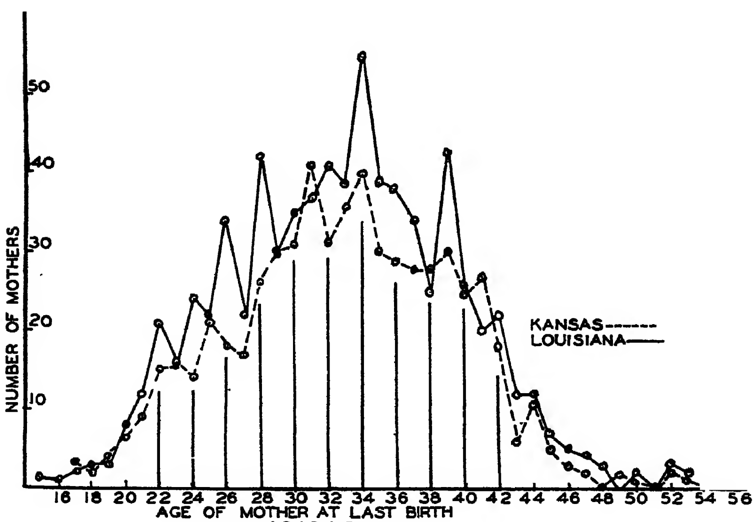
12
13
14
15
YEARS OF INTERVAL
GRAPH 3



GRAPH 4



GRAPH 5

Notes on Additional Fauna of Edson Quarry of the Middle Pliocene of Kansas

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ABSTRACT: Notes on new fossil mammals from the Edson Quarry, Middle Pliocene of Kansas. The following are described as new: *Perognathus dunklei* sp. nov.; *Prodipodomys* gen. nov., Genotype *Dipodomys kansensis* Hibbard and ?*Oryzomys pliocaenicus* sp. nov.

The specimens which form the basis of this report were collected by Mr. David Dunkle from the Edson Quarry in Sherman county, Kansas, in the spring of 1935. They are now a part of the collection of the Museum of Comparative Zoölogy at Harvard. For permission to study and describe these specimens I am indebted to Dr. Alfred S. Romer.

ORDER INSECTIVORA

Family TALPIDAE

(Fig. 1)

A right humerus (M. C. Z. No. 6200) represents a mole slightly larger than *Scalopus a. machrinoides*. The humerus, though not complete, is different in many respects from that of *Scalopus* and *Scapanus*. More complete material is needed for generic identification, though it seems to represent an extinct genus.

The humerus is not as compact as in *Scalopus a. machrinoides*. The articular surface for the radius is larger, though the condylus internus is not as strongly developed or curved as in *Scalopus* or *Scapanus*. The articular surface for the ulna is intermediate in size. The articular surfaces for the scapula and clavicle are missing.

Another right humerus (K. U. M. V. P. No. 4928) represents a mole the size of *Scalopus a. texanus*. The humerus corresponds in shape to the preceding humerus but differs in size. Both are from adult specimens. It possesses the articular surface for the clavicle, though the spurlike processes are broken off from all of the condyles.

ORDER RODENTIA

Family HETEROMYIDAE

Perognathus dunklei sp. nov.

(Figs. 2 and 3)

Holotype. No. 6203 Museum of Comparative Zoölogy, Harvard; right lower jaw, bearing P_4 — M_2 and alveolus of M_3; incisor, angle, condyle and coronoid process missing. Referred material, anterior portion of right lower jaw (No. 6203a M. C. Z.) with incisor and P_4. Collected by David Dunkle, spring of 1935.

Horizon and Type Locality. Middle Pliocene, Ogallala formation, Edson Quarry, Sherman county, Kansas; sec. 25, T. 10 S., R. 38 W.

Diagnosis. Smallest of the known fossil forms of the genus *Perognathus*. External cusps of protoloph and metaloph of M_1 strongly developed; M_1 and M_2 medium crowned.

Description of Type. Perognathus dunklei represents a form the size of *Perognathus f. flavus.*

P_4 is high crowned and the cusps have completely worn down. The median valley of M_1 is still present. The tooth is more rounded than in *Perognathus f. flavus.* The lophs and cusps have remained distinct through a longer period of wear than in recent forms of corresponding age. M_1 has well-developed roots and is larger than M_2. M_2 is well rooted and larger than P_4. It is more rectangular in shape than M_1. M_3 was well developed though smaller than M_2 and possessed two well-developed roots; the anterior being the larger. Alveolar length of P_4-M_3 series, 3 mm.; anteroposterior diameter of P_4-M_2, inclusive, 2.1 mm.; transverse diameter of P_4, 0.6 mm.; transverse diameter of M_1, 0.9 mm.; transverse diameter of M_2, 0.83 mm. The fragmentary jaw is so set in plaster that it is impossible to see the mental foramen or the masseteric ridge.

The fossil species differs from the recent forms in that the cusps are more strongly developed, giving a deeper median valley between the lophs of M_1 and M_2.

Prodipodomys gen. nov.

Genotype. Dipodomys kansensis Hibbard. Amer. Midland Naturalist, Vol. 18, No. 3, pp. 462-464, Fig. 3, May, 1937.

Horizon and Type Locality. Middle Pliocene, near the base of the Ogallala formation, Sherman county, Kansas; sec. 25, T. 10 S., R. 38 W.; Edson Quarry.

Generic Diagnosis. P_4 high crowned, with two roots and X pattern, smaller than M_1 and as large as M_2 or larger; M_1 and M_2 subequal; M_3 greatly reduced, considerably smaller than P_4 and M_2; M_1 with two well-developed roots; M_2 strong tendency toward single root, a shallow groove on labial side of root of tooth showing incomplete reduction; M_3 single rooted; masseteric ridge well developed, ending in a strong process and situated as in *Dipodomys*. Tendency toward a slight pit between M_3 and coronoid process; a large foramen is present slightly posterior and labial to M_3, its form and position is the same as in *Dipodomys*.

Remarks. The presence of the rooted condition of P_4 and M_1 and the incomplete fusing of the root in M_2 seems to necessitate the founding of a new genus of kangaroo rats. *Prodipodomys* is distinguished from *Cupidinimus* by the presence of a well-developed foramen between M_3 and the base of the coronoid, which corresponds exactly with that found in *Dipodomys*. *Prodipodomys* is distinguished from *Dipodomys* by the presence of rooted P_4 and M_1.

In the M. C. Z. collection is a specimen No. 6204 (fig. 4) collected by David Dunkle, spring 1935, from Edson Quarry, which is questionably referred to *Prodipodomys kansensis*. The specimen consists of left maxilla bearing M^1 and M^2. In size they correspond with the type. P^4 is rooted. The alveolus is so broken that the development of the roots is not clearly shown, but there is evidence that the tooth possessed three roots. The anterior and labial roots

seem smaller than the lingual root. M^1 is high crowned with two well-developed roots. M^2 roots nearly fused. M^3 has a single root. M^1 larger than M^2. Alveoli length of P^4-M^3 series, 4.6 mm. Transverse width of M^1, 1.4 mm. Transverse width of M^2, 1.2 mm.

Family Cricetidae

Peromyscus martinii Hibbard

(Fig. 5)

In the collection is a nearly perfect right lower jaw (No. 6201 M. C. Z.) bearing incisor, M_1 and M_2. It is referable to the above form. The size and dentition pattern of the teeth agree in all respects with those of the type. Molar teeth simple and without accessory cusps. Length of tooth series (M_1-M_3) from the posterior edge of the alveolus of M_3 to the anterior edge of the alveolus of M_1 is 4 mm.; depth of mandible below posterior root of M_1 is 3 mm.; length of diastema from anterior border of M_1 to posterior border of the incisor alveolus, 3.5 mm. M_1 does not possess an anterior re-entrant angle. The masseteric ridge and mental foramen is normally developed and corresponds to those of *Peromyscus leucopus aridulus*. In comparison of the fossil specimen with the lower jaws of an adult female of *Peromyscus leucopus aridulus* it is found that the capsular process for the reception of the base of the incisor corresponds in development and position to the recent form. The distance from the alveolar border of M_3 to the condyle is 1.5 mm. greater in *P. l. aridulus* than in the fossil form.

?Oryzomys pliocaenicus sp. nov.

(Fig. 6)

Holotype. No. 6202, Museum of Comparative Zoölogy, Harvard; left lower jaw, bearing incisor, M_1, M_2 and M_3; angle, condyle and coronoid process missing. Collected by David Dunkle, spring of 1935.

Horizon and Type Locality. Middle Pliocene, Ogallala formation, Edson Quarry, Sherman county, Kansas; sec. 25, T. 10 S., R. 38 W.

Diagnosis. A small cricetine rodent with masseteric ridge developed and situated as in the genus *Oryzomys*. Mental foramen situated on dorsal surface of diastemal region. Anteroposterior diameter of M_1-M_3 series is 3.6 mm.

Description of Type. The mandible is that of an old specimen with teeth greatly worn, only the outlines of the cusps remaining. No accessory cusps present. The masseteric ridge corresponds in development to that found in the genus *Oryzomys*. The mental foramen is situated slightly more dorsally on the diastemal region than in *Oryzomys palustus texensis*. The depth of the mandible below M_1 is 3.6 mm.

Remarks. This specimen is placed questionably in the genus *Oryzomys*. Incomplete material, the form and position of the masseteric ridge, also the position of the mental foramen, prohibit the placing of the specimen with the following genera: *Onychomys, Reithrodontomys, Peromyscus* or *Eligmodontia*. The depth of the mandible correlated with the size of the jaw is also characteristic and resembles more closely the condition observed in *Oryzomys*. If the jaw were complete so that one could study the development and situa-

tion of the capsular process for the reception of the base of the incisor, more light would be thrown upon the relationship of the species.

The following fauna has been found associated with the newly described forms from the Edson Quarry = "Edson Beds" = "North Quarry":

AMPHIBIA
- Ambystomidae
  - *Plioambystoma kansensis* Adams
- Pelobatidae
  - *Scaphiopus pliobatrachus* Taylor
- Bufonidae
  - *Bufo arenarius* Taylor
  - *Bufo hibbardi* Taylor

REPTILIA
- Chelydridae
  - *Chelonia* sp.
- Testudinidae
  - *Testudo* sp.

AVES
- Colymbidae
  - *Colymbus nigricollis*
- Gruidae
  - *Grus nannodes* Wetmore and Martin
- Scolopacidae sp.
- Corvidae sp.

MAMMALIA
- Mustelidae
  - *Martinogale alveodens* Hall
  - *Plesiogulo marshalli* (Martin)
- Canidae
  - *Osteoborus cyonoides* (Martin)
  - *Leptocyon shermanensis* Hibbard
- Felidae
  - *Machairodus* cf. *catocopis* Cope
  - *Adelphailurus kansensis* Hibbard
- Mylagaulidae
  - *Mylagaulus monodon* Cope
- ? Family
  - *Kansasimys dubius* Wood
- Heteromyidae
  - *Prodipodomys kansensis* (Hibbard)
- Cricetidae
  - *Peromyscus martinii* Hibbard
- Camelidae
  - *Megatylopus gigas* Matthew and Cook
  - *Pliauchenia* sp.
- Tayassuidae
  - *Prosthennops serus* Cope

Equidae
Hipparion cf. *montezumae* (Leidy)
Pliohippus cf. *pernix* Marsh
Calippus ansae Matthew and Stirton
Rhinocerotidae
Aphelops cf. *mutilus* Matthew

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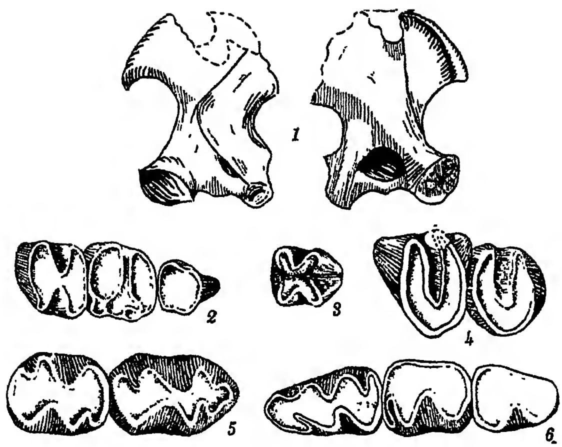

FIG. 1. *Talpidae,* right humerus, K. U. M. V. P. No. 4928, × 2.

FIG. 2. *Perognathus dunklei* Hibbard, type, M. C. Z., No. 6203, right lower P_4, M_1 and M_2, × 10.

FIG. 3. *Perognathus dunklei,* right lower P_4, M. C. Z. No. 6203a, × 10.

FIG. 4. *Prodipodomys kansensis,* M. C. Z. No. 6204, left upper M^1 and M^2, × 10.

FIG. 5. *Peromyscus martinii,* M. C. Z. No. 6201, right lower M_1 and M_2, × 10.

FIG. 6. *?Oryzomys pliocaenicus* Hibbard, type, M. C. Z. No. 6202, left lower M_1, M_2, and M_3, × 10.

Notes on Some Mammals from the Pleistocene of Kansas

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ABSTRACT: Notes on the occurrence of *Bison* sp., *Smilodon* sp., *Felis* cf. *imperialis, Felis* cf. *oregonensis, Felis atrox, Aenocyon dirus, Cynomys l. ludovicianus, Castor* sp., *Camelops kansanus, Odocoileus* sp., *Equus francisci, Equus niobrarensis* and *Parelephas* cf. *columbi* in the Pleistocene of Meade and Harvey counties, Kansas, with five plates of 23 figures.

INTRODUCTION

The following mammals were collected by the Museum field parties during the summers of 1937 and 1938 or they were donated during that period to the Museum of Vertebrate Paleontology.

During our intensive work in southwestern Kansas in the past two summers on the Upper Pliocene deposits a number of Pleistocene deposits have been revisited, or located for the first time. These deposits have not been worked, but only the exposed material removed. It is the plan of the Museum to begin work in these deposits in the near future. A few of the deposits should yield a number of vertebrates, but none of the deposits promise to yield a large or nearly complete fauna. Enough material may be recovered from the scattered deposits to work out their relationships so that an attempt may be made to correlate them with deposits of other regions.

From all of the deposits reported in this paper there was collected a large number of terrestrial and fresh-water gastropods and some pelecypods in association with the vertebrates. Dr. Frank C. Baker of the University of Illinois is now studying these invertebrates.

In 1935 we visited an exposure on the Big Springs Ranch, from which were recovered the mammals reported in Kan. Acad. Sci., 40:234, 1937. At the time of the first visit it was evident that the place had been worked some years before. Since the deposit is above flood stage of Spring creek the old signs of digging still remained, along with fragments of fossils. In the summer of 1937 we returned to the locality and were fortunate to find still living in the Big Springs ranch house an old gentleman who had always lived on the ranch and who was there at the time F. W. Cragin made a study of the Pleistocene along Spring creek in 1891 in Meade county; he told us of Cragin's work and the fossils that he had taken to Colorado. He took us to the place where Cragin had collected the fossils and it was the same place that we had visited in 1936. He assured us that the diggings now evident at the locality were of a later date, those left by Mr. Sternberg when he later worked in Cragin Quarry. The deposit has never been thoroughly worked. Doctor Cragin was only there for a few days, but he expected to return to open the deposit; Mr. Sternberg's visit was also short, and we were only able to spend a part of a day in 1937. It is of great interest to know the exact

locality and horizon in which Cragin collected his vertebrates on Spring creek in 1891; the place is now known in our catalogues as Meade county, locality No. 6, Cragin's Quarry.

The material from Harvey county, locality No. 1, was collected by Kenneth Scott, who received permission from Mr. Gatz, upon whose land they occurred. The material was donated to the museum by Mr. Scott. We are indebted to Mr. Gatz, the owner of the land, and to Mr. Scott, who collected the material, for their interest in science and coöperation with the Museum in seeing that the material was made available for study and exhibition.

The Harvey county deposit occurs in an old stream bed where the vertebrates are found in a layer of heavily cemented rusty gravel about four inches in thickness. Above the gravel is nearly fifteen feet of blue clay. The deposit rests upon the Permian. The present-day stream has cut through the Pleistocene and into the Permian, leaving an exposure of a good section of Pleistocene.

The bison from Wilson county was found by Mr. Fred Stroud in a gravel deposit along the bank of the Fall river. We are indebted to Mr. Stroud for the loan of this specimen for study and exhibit.

In the collection of fossils it is impossible to credit each fossil to a given member of the field party, since in many cases the entire party spends considerable time in taking out a single specimen. Therefore it has been customary to list the party of a given summer as the collector of the material for that summer. I wish to thank the members of our parties for their untiring interest and careful work while in the field. The following were members of our party for 1936, Joe Tihen, Francis Parks, and Otto Tiemeier; Summer of 1937, Joe Tihen, Harry Jacob, Vernon Carter, Fred Holden and Benedict Bagrowski; Summer of 1938, Joe Tihen, Harry Jacob, and James Sprague.

I wish to thank Mr. Brother Buis, of Meade, Kan., and Mr. Cochran, foreman of the XI Ranch, for the interest they have shown in our work and coöperation they have given us while working in Meade county.

The drawings were made by Miss Frances B. Watson with the exception of Plate I, fig. 2, which was made by Walter Yost.

Aenocyon dirus (Leidy)

(Plate I, fig. 2)

Little is known of the Pleistocene Canidae of Kansas. *Aenocyon dirus* has been reported by Merriam (Memoirs Univ. Cal., 242-243:1912) from the Sheridan Formation of Kansas.

A left lower jaw of an old individual, No. 4613 K. U. M. V. P., seems referable to the above species. The specimen was collected by the K. U. field party during the summer of 1937, from locality No. 7, on the XI Ranch, Meade county, Kansas. Associated with the lower jaw was an upper canine and both I^3. Due to the uncorrelated Pleistocene beds of Meade county it is impossible to assign the fossil to any given phase, especially since it was not associated with any other vertebrates. It was taken from an old stream channel now well above the flood plain of the present Cimarron river. In the channel are lenses of sand overlaid by a bluish-brown clay. The jaw occurred in a zone with invertebrates which may help in the future to correlate the Pleistocene beds of southwestern Kansas. In the following table are given

measurements, in millimeters, of the two specimens from Kansas. The measurements of the specimen from the Sheridan Formation, No. 10391 Amer. Mus. Nat. Hist., are taken from Merriam.

TABLE I

	A. dirus ? Sheridan Formation, Kansas (Amer. Mus., No. 10391)	*A. dirus* Meade Co., Kansas (K. U. M. V. P., No. 4613)
I_3 greatest transverse diameter	....	6.6
C greatest anteroposterior diameter at lower edge of enamel	....	13.5
P_1 greatest anteroposterior diameter	6.3	7.35
P_2 greatest anteroposterior diameter	14.7	14.5
P_3 greatest anteroposterior diameter	15.5	17.1
P_4 greatest anteroposterior diameter	19.9	18.2
M_1 greatest anteroposterior diameter	33.7	32.8
M_1 greatest anteroposterior diameter of heel, on outer side	8.2	8.6
M_1 greatest transverse diameter of heel	12.6	11.1
M_1 greatest transverse diameter of trigonid	13.8	12.6
M_2 greatest anteroposterior diameter	12.5 ap.	13.0
M_2 greatest transverse diameter	10.0	9.5
M_3 greatest anteroposterior diameter	....	7.0
I^3 greatest anteroposterior diameter	....	11.0
C greatest anteroposterior diameter at upper edge of enamel	....	15.5
Length of lower jaw from condyle to anterior side of canine	198.0	199.0
Depth of lower jaw at condyle	48.0	43.2
Depth of lower jaw at M_1	39.5 ap.	39.7
Length from posterior side of M_3 to anterior side of canine	133.0 ap.	132.0
Length of inferior molar and premolar series	110.0 ap.	109.0

Smilodon sp.

The posterior part of a right P^4, No. 3657 K. U. M. V. P., belonging to a young individual is referred to the above genus. The tooth represents a small form of the "Saber toothed" cats which was taken from the Cragin Quarry in association with the two forms of the true cats.

Felis cf. *imperialis* Leidy

(Plate I, fig. 3)

In the collection made on the Big Springs Ranch during the summer of 1937, at the site of the old Cragin Quarry (Meade county, locality No. 6) there was taken a left M_1, No. 4625 K. U. M. V. P., of a cat the size of the African lion which seems referable to the above species. The greatest anteroposterior diameter is 26 mm., the greatest transverse diameter is 12.8 mm. The tooth is that of an adult cat.

Due to the fragmentary condition of the type of *Felis imperialis* and the scarcity of true cat remains from the Pleistocene of North America, little is known of its relationship to other species.

Associated with the M_1 was a fifth left metacarpal, No. 4629 K. U. M. V. P., larger than that of an African lion. Total length of the metacarpal is 110 mm. The metacarpal seems too long to be of the same individual as the M_1, especially if the African lion skeleton is to be used for comparison. (See Plate I, fig. 1.) Hay reported (K. U. Sci. Bul., vol. 18, No. 2, 1917) from the same quarry the remains of an undetermined *Felid* somewhat larger than the African lion.

Felis cf. *oregonensis* Rafinesque

(Plate I, fig. 5)

Associated with the large M_1, No. 4625 K. U. M. V. P., was the right M_1, No. 4626 K. U. M. V. P., of a cat the size of our present day mountain lion. The posterior root and part of the crown is missing. The tooth is that of an adult cat.

Felis cf. *atrox* Leidy

(Plate II, figs. 6 and 6a)

In the collection of vertebrates taken from the Pleistocene deposit in Harvey county, Kansas, locality No. 1, is a femur, No. 4646 K. U. M. V. P., belonging to a cat larger than the African lion. The femur was compared with the femora of *Felis leo,* Amer. Mus., No. 80609 ♂, and *Felis tigris,* Amer. Mus., No. 54460 ♂. Due to the differences found in the fossil femur in comparison to that of our recent large cats, the following discussion is given. The shaft of the fossil femur is slightly more curved than that of *Felis leo.* When it is laid on its back on a flat surface, we find the following parts touching that surface: the posterior inter-trochanteric ridge, the lesser trochanter, the posterior faces of the internal and external condyles. This condition was not observed in the lion or tiger.

The linea aspera is well developed and rounded, resembling that of the tiger. In *Felis leo* the posterior inter-trochanteric ridge is well developed and extends from the great trochanter to the lesser trochanter, while the ridge in the fossil form shows no tendency to extend to the lesser trochanter, but ends as in *Felis tigris.* The trochanteric fossa compares more closely with that of *Felis leo,* but differs in that the neck of the femur is more distinctly developed. The pit on the head of the femur for the attachment of the ligamentum teres is as well developed as in *F. tigris.*

The only marked difference of the distal end of the femur is that the intercondyloid fossa is narrower and deeper than that of *F. leo.* The femur is distinct from that of both the lion and the tiger. The length of the femur is 378 mm.

I wish to thank Dr. H. E. Anthony, Curator of Mammals of the American Museum of Natural History, for the loan of recent material used in the comparative study.

Associated with the femur was a large distal phalanx showing the heavy development of the claw. The femur has been referred to *Felis atrox* due to its large size and heavy development.

Parelephas cf. *columbi*

A well-preserved femur, No. 4633 K. U. M. V. P., referred to above form was taken from locality No. 1, Harvey county, Kansas, in association with the large *Bison* sp., *Equus* sp., *Odocoileus* sp. and *Felis* cf. *atrox.*

Measurements in millimeters of the femur, No. 4633 K. U. M. V. P.:

Length	1085
Anteroposterior diameter at narrowest point of shaft	75
Transverse diameter at narrowest point of shaft	141
Circumference at narrowest point of shaft	370
Greatest circumference of head of femur	495

Associated with the *Bison* skull, No. 4927 K. U. M. V. P., from Wilson county, Kansas, were sections of an elephant tooth referable to the above form.

Equus francisci Hay

(Plate III, figs. 7 and 8)

In the collection from Cragin's Quarry are the associated lower jaws of a small horse, No. 4627 K. U. M. V. P., which is referred to the above species. The dentition is that of an old animal and shows considerable differences in dentition pattern from that of *E. francisci;* most of the differences are probably due to the age of the individual, as shown by the wearing of the crowns. Due to the insufficient material known of *E. tau* and *E. littoralis* it is impossible to make comparison with these forms. The Kansas specimen seems to be intermediate in size. This is the smallest *Equus* ever found in the Pleistocene of Kansas. *Equus leidyi* was reported by Hay from the same locality and it is also known from other localities in Kansas.

Measurements of the right lower teeth, in millimeters, of *E. francisci,* No. 4627 K. U. M. V. P.:

Length of the premolar-molar series	133.0
Length of the premolar series	66.1
P_2, Length of grinding surface	23.4
Greatest width of grinding surface	12.7
Height of crown above alveolar border	13.8
P_3, Length of grinding surface	21.8
Greatest width of grinding surface	12.2
Height of crown above alveolar border	10.6
P_4, Length of grinding surface	21.2
Greatest width of grinding surface	13.5
Height of crown above alveolar border	10.2
Length of molar series	66.1
M_1, Length of grinding surface	18.7
Greatest width of grinding surface	13.6
Height of crown above alveolar border	9.1
M_2, Length of grinding surface	20.5
Greatest width of grinding surface	12.7
Height of crown above alveolar border	10.9
M_3, Length of grinding surface	26.2
Greatest width of grinding surface	11.0
Height of crown above alveolar border	11.0

Equus niobrarensis Hay

(Plate IV, figs. 12, 15, 16, 17 and 18)

Probably no form is as well known from the Tertiary and Quaternary deposits as the horse, from isolated bones and teeth, yet despite this mass of accumulated material little is known of the different forms and their variations. Hay referred a few teeth from Cragin's Quarry to *Equus complicatus.* The teeth collected from the same place in 1937 are here referred to *E. niobrarensis,* after a comparison with specimens taken from the type locality. Until more is known about the Pleistocene horses, one cannot secure a complete picture of their distribution through time and space. The finding of more complete specimens in the future showing the range of variations within a given form should help greatly in the identification of our Pleistocene material. I have figured a number of upper premolars, which I have considered as *Equus niobrarensis,* to show the change in dentition pattern due to wear.

Measurements, in millimeters, of P^2 of *Equus niobrarensis:*

K. U. M. V. P.	*Height*	*Length*	*Width*	*Protocone*
4796	75	40	27.5	11
2821	72	41	28	11
400	68	38	26	11
399	50	40	27	11
2821a	20	41	24	8.5

Specimens numbers 2821 K. U. M. V. P. and 2821a K. U. M. V. P. were collected by H. T. Martin at Hays Springs, Neb., at the same place the type was taken; No. 399 K. U. M. V. P. was collected by H. T. Martin in 1893 from the Sternberg elephant bed in Lane county, Kansas; No. 400 K. U. M. V. P. was taken from Cragin Quarry, locality No. 6, Meade county, Kansas, summer of 1937; and No. 4796 K. U. M. V. P. was taken from locality No. 8, Meade county, Kansas, summer of 1937.

Equus sp.

A lower molar, No. 4642 K. U. M. V. P., was taken in Harvey county, Kansas, locality No. 1, 1938. It has been figured because of its associations with the other vertebrates described in this paper. (See Plate IV, fig. 11.)

A part of a skull, No. 4790 K. U. M. V. P. (Plate IV, fig. 14), was recovered from a road cut in Meade county, Kansas, known as locality No. 8. We are indebted to Dr. H. T. U. Smith who found this specimen and coöperated with our work during the summers of 1937 and 1938 in southwestern Kansas. The dentition is good enough to warrant figuring. From this locality were taken a number of horse limb bones and teeth, including No. 4796 K. U. M. V. P., which I have referred to *Equus niobrarensis*. On account of the dentition pattern, which may be entirely the result of wear in an old individual, I have hesitated to assign it to any species. It seems to me to be distinct from *E. niobrarensis*.

Table of Measurements of *Equus* skull No. 4790 K. U. M. V. P.:

From front of premaxillae to front of posterior nares	300.0 mm.
From front of premaxillae to rear of notch between nasal and premaxillae	220.0 mm.
From front of premaxillae to front of orbit	365.0 mm.
From front of premaxillae to front of P^2	150.0 mm.
From posterior alveolar border of C to front of P^2	71.3 mm.
Length of diastema between I^3 and C	26.0 mm.
Length of molar-premolar series	185.0 mm.
Length of premolar series	97.5 mm.
Height of crown of P^2 above alveolar border	20.5 mm.
P^2, Length	40.2 mm.
Width	24.1 mm.
Protocone	10.6 mm.
P^3, Length	26.3 mm.
Width	27.3 mm.
Protocone	12.8 mm.
Length of molar series	87.0 mm.
M^1, Length	23.6 mm.
Width	27.0 mm.
Protocone	12.5 mm.
M^2, Length	25.6 mm.
Width	25.2 mm.
Protocone	12.5 mm.
M^3, Length	32.8 mm.
Width	26.0 mm.
Protocone	15.9 mm.

Camelops kansanus Leidy

(Plate III, figs. 9 and 10)

Cragin (Colo. College Studies, 6: 53, 1896) and Hay (K. U. Sci. Bull., 18: No. 2, 1917) referred the camel material from the Big Springs Ranch, Meade county, locality No. 6, to *Camelops heurfanensis*. Hibbard (Trans. Kan. Acad. Sci., 40: 234, 1937) referred the teeth from the same quarry to *C. kansanus*.

Among the material taken from the Cragin Quarry during the summer of 1937 were a number of elements belonging to a large camel. The material consisted of two astraguli, a calcanium, incisors, canines, and parts of two

lower jaws with well-worn dentition. A study of this material reveals that there are no characters which separate it from Leidy's *C. kansanus*. The differences between the two species seem to fall within the range of sexual, age and individual variation.

The lower jaws, No. 4628 K. U. M. V. P., are from the same individual, each bearing P_4 to M_3, inclusive. The measurements are given for the left lower jaw:

Length of P_4 to M_3 series	157.0 mm
Anteroposterior diameter of P_4	25.4 mm
Greatest transverse diameter of P_4	14.3 mm.
Anteroposterior diameter of M_1	30.5 mm
Greatest transverse diameter of M_1	20.0 mm.
Anteroposterior diameter of M_2	42.0 mm
Greatest transverse diameter of M_2	22.2 mm
Anteroposterior diameter of M_3	62.0 mm.
Greatest transverse diameter of M_3	21.5 mm.

Bison sp.

In the collection of vertebrates from Harvey county, Kansas, locality No. 1, there has been restored the base of a bison skull, No. 4634 K. U. M. V. P., with one complete horn core. The skull at the time of exposure was nearly perfect, with complete horn cores, and maxillaries with teeth. Only one molar was recovered, and fragmentary parts of the skull, with atlas, a few cervical vertebrae and the right half of the lower jaw. The horn cores represent a form considerably larger than *Bison occidentalis*. (See Plate V, figs. 20, 21 and 22.)

Measurements, in millimeters, of *Bison* sp., No. 4634 K. U. M. V. P., from Harvey county, Kansas:

Vertical diameter of horn core at base	100.0
Transverse diameter of horn core at base	147.0
Circumference of horn core at base	425.0
Length of horn core along upper curve	530.0
Length of horn core along lower curve	610.0
Width between tips of horn cores	1180.0 ap.

A bison skull with perfect horn cores, No. 4927 K. U. M. V. P., from Wilson county, Kansas, has been loaned to Kansas University Museum of Vertebrate Paleontology by Mr. Fred Stroud, of Fredonia, Kan. Mr. Stroud recovered the skull from the banks of the Fall river at the base of a four-foot gravel deposit which is covered by a deposit of clay ranging from twenty to twenty-five feet in depth.

Measurements in millimeters of *Bison* sp., No. 4927 K. U. M. V. P., from Wilson county, Kansas. (See Plate V, fig. 19.)

Vertical diameter of horn core at base	132.0
Transverse diameter of horn core at base	132.0
Circumference of horn core at base	433.0
Length of horn core along upper curve	440.0
Length of horn core along lower curve	483.0
Width between tips of horn cores	1128.0

Odocoileus sp.

(Plate IV, fig. 13)

A single left upper molar, No. 4643 K. U. M. V. P., was taken from locality No. 1, Harvey county, which belongs to a small deer of this genus about the size of an antelope.

Cynomys l. ludovicianus

A right lower jaw, No. 4614 K. U. M. V. P., of a prairie-dog, which corresponds in detail with that of the species now occurring in Kansas, was taken in association with *Equus niobrarensis* at locality No. 8, Meade county, Kansas. From a study of the section and the relationship of the jaw with the horse material there seems to be no question but that the jaw is of the same age. Probably no group of vertebrates requires as careful collecting as the remains of burrowing rodents in our Tertiary and Quaternary deposits.

Castor sp.

(Plate I, fig. 4)

The right M_1 taken on the XI Ranch, locality No. 7, near the top of the section represents the first evidence of Castor in the Pleistocene of Kansas. The dentition pattern is peculiar; whether it represents only individual variation is uncertain.

EXPLANATION OF PLATES

PLATE I

FIG. 1. *Felis* cf. *imperialis* Leidy, fifth left metacarpal of K.U.M.V.P., No. 4629, $\times$ 1.

FIG. 2. *Aenocyon dirus* (Leidy), left lower jaw of K.U.M.V.P., No. 4613, $\times$ ½.

FIG. 3. *Felis* cf. *imperialis* Leidy, left M_1 of K.U.M.V.P., No. 4625, $\times$ 1.

FIG. 4. *Castor* sp., right M_1 of K.U.M.V.P., No. 4727, $\times$ 1.

FIG. 5. *Felis* cf. *oregonensis* Rafinesque, right M_1 of K.U.M.V.P., No. 4626, $\times$ 2.

PLATE I

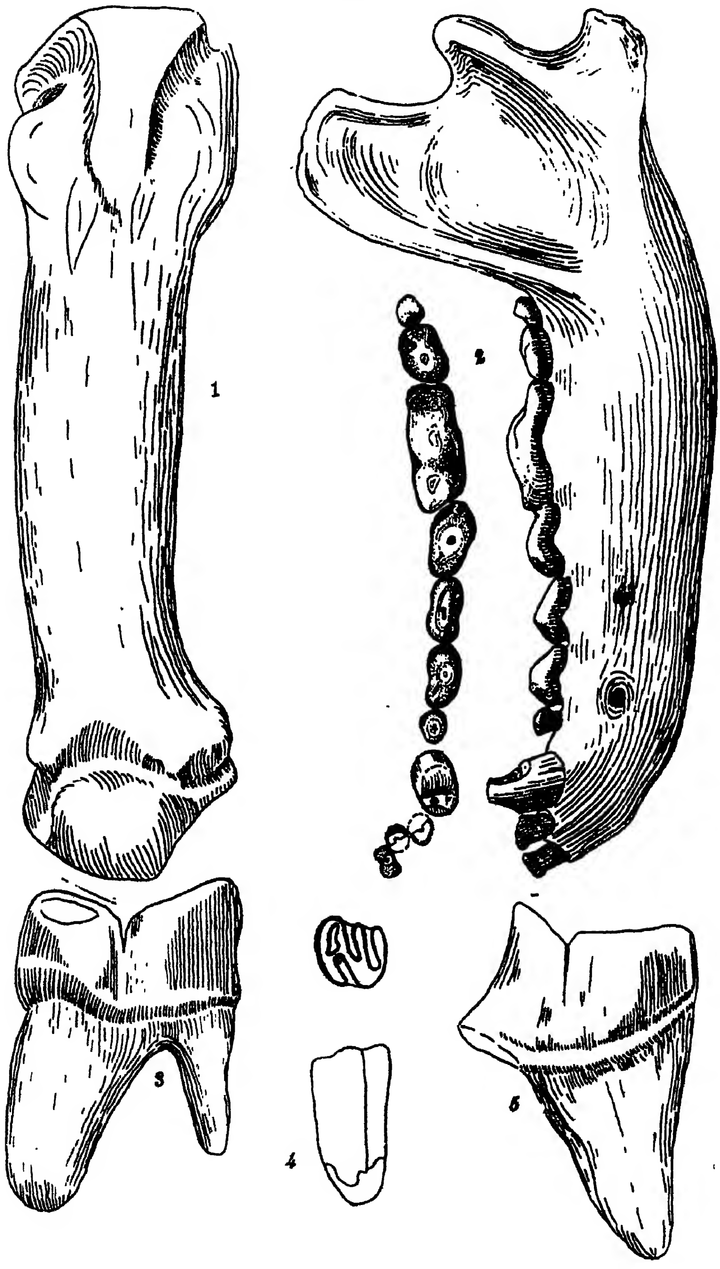
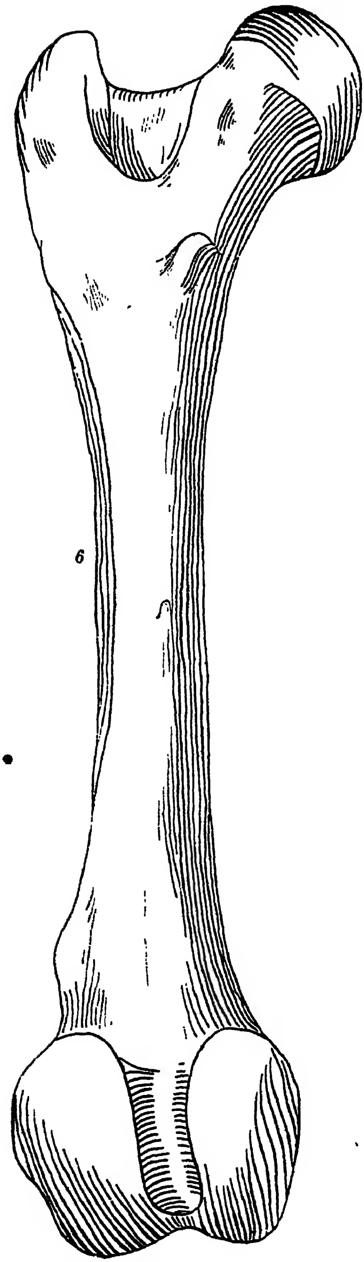


PLATE II

FIG. 6. *Felis* cf. *atrox* Leidy, left femur, posterior view of K.U.M.V.P., No. 4646, × 4/9 ap.

FIG. 6a. *Felis* cf. *atrox* Leidy, left femur, anterior view of K.U.M.V.P., No. 4646, × 4/9 ap.

PLATE II



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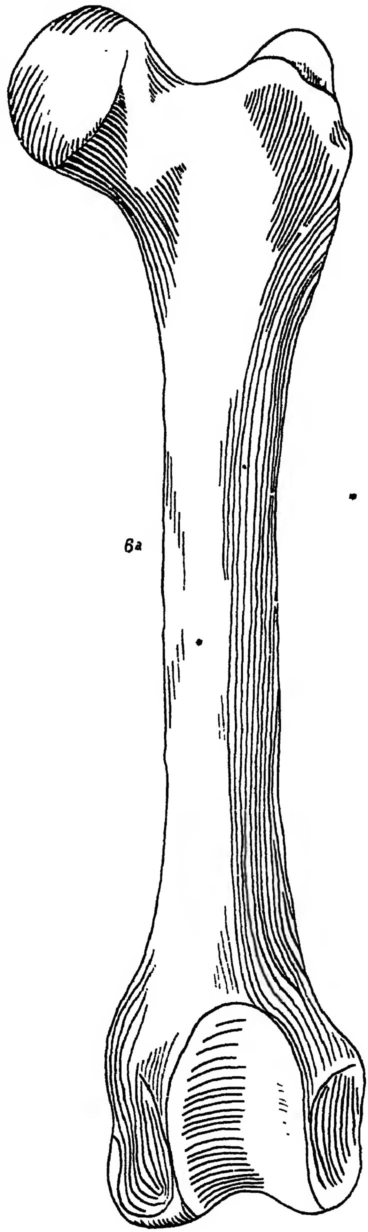

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PLATE III

FIG. 7. *Equus francisci* Hay, right lower jaw bearing P_2-M_3 of K.U.M.V.P., No. 4627, × 1.

FIG. 8. *Equus francisci* Hay, left lower jaw bearing P_2-M_3 of K.U.M.V.P., No. 4627, × 1.

FIG. 9. *Camelops kansanus* Leidy, right lower jaw bearing P_4-M_3 of K.U. M.V.P., No. 4628, × 1.

FIG. 10. *Camelops kansanus* Leidy, left lower jaw bearing P_4-M_3 of K.U.M. U.V.P., No. 4626, × 1.

PLATE III

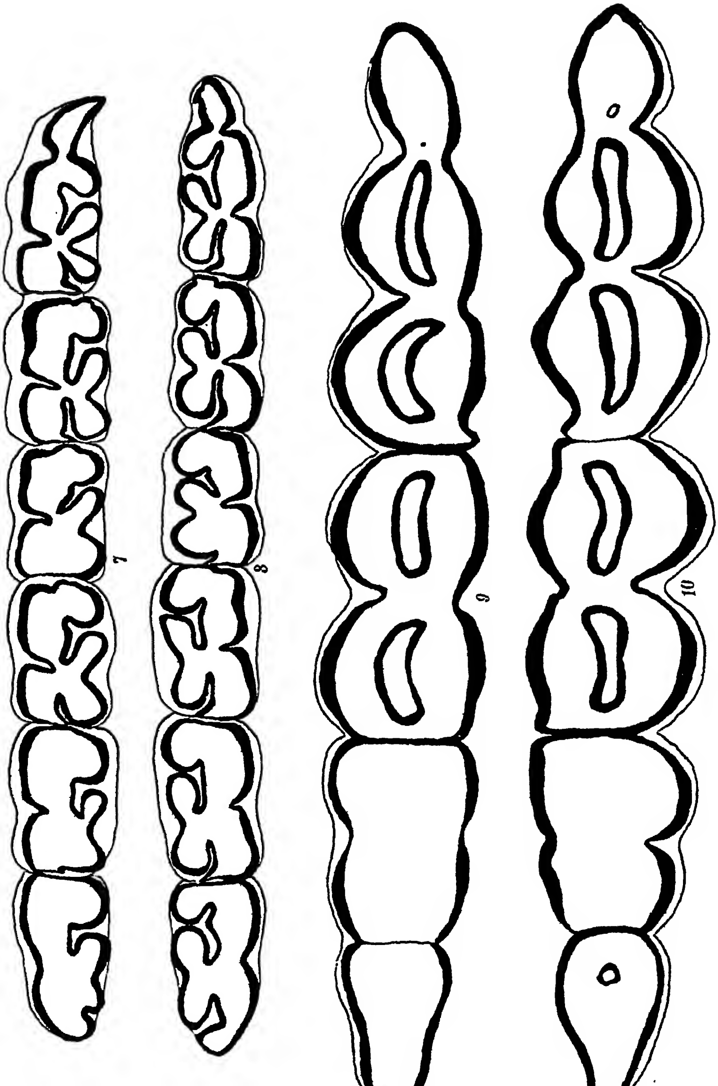


PLATE IV

FIG. 11. *Equus* sp., lower molar of K.U.M.V.P., No. 4642, $\times$ 1.

FIG. 12. *Equus niobrarensis* Hay, left P^2 of K.U.M.V.P., No. 4796, $\times$ 1.

FIG. 13. *Odocoileus* sp., left upper molar of K.U.M.V.P., No. 4643, $\times$ 2.

FIG. 14. *Equus* sp., right P^2-M^3 of K.U.M.V.P., No. 4790,$\times$1.

FIG. 15. *Equus niobrarensis* Hay, left P_2 of K.U.M.V.P., No. 400, $\times$ 1.

FIG. 16. *Equus niobrarensis* Hay, right P^2 of K.U.M.V.P., No. 2821, $\times$ 1.

FIG. 17. *Equus niobrarensis* Hay, right P^2 of K.U.M.V.P., No. 399, $\times$ 1.

FIG. 18. *Equus niobrarensis* Hay, right P_2 of K.U.M.V.P., No. 2821a, $\times$ 1.

PLATE IV

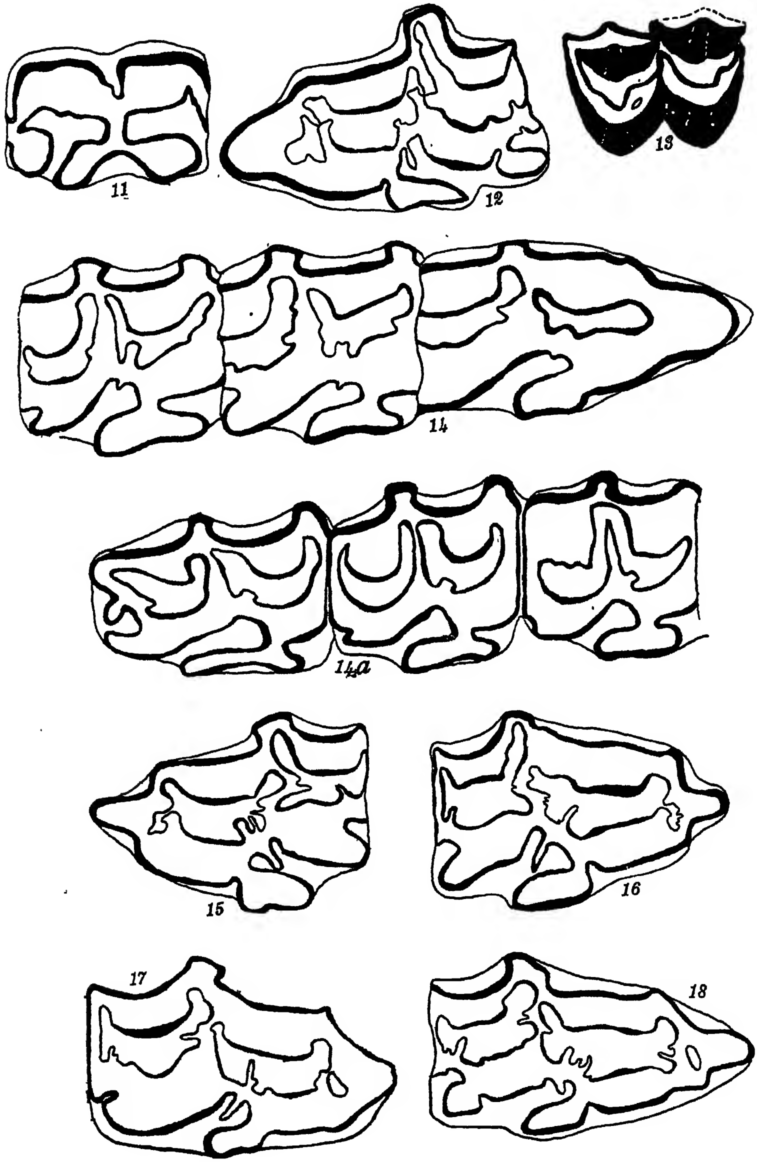


PLATE V

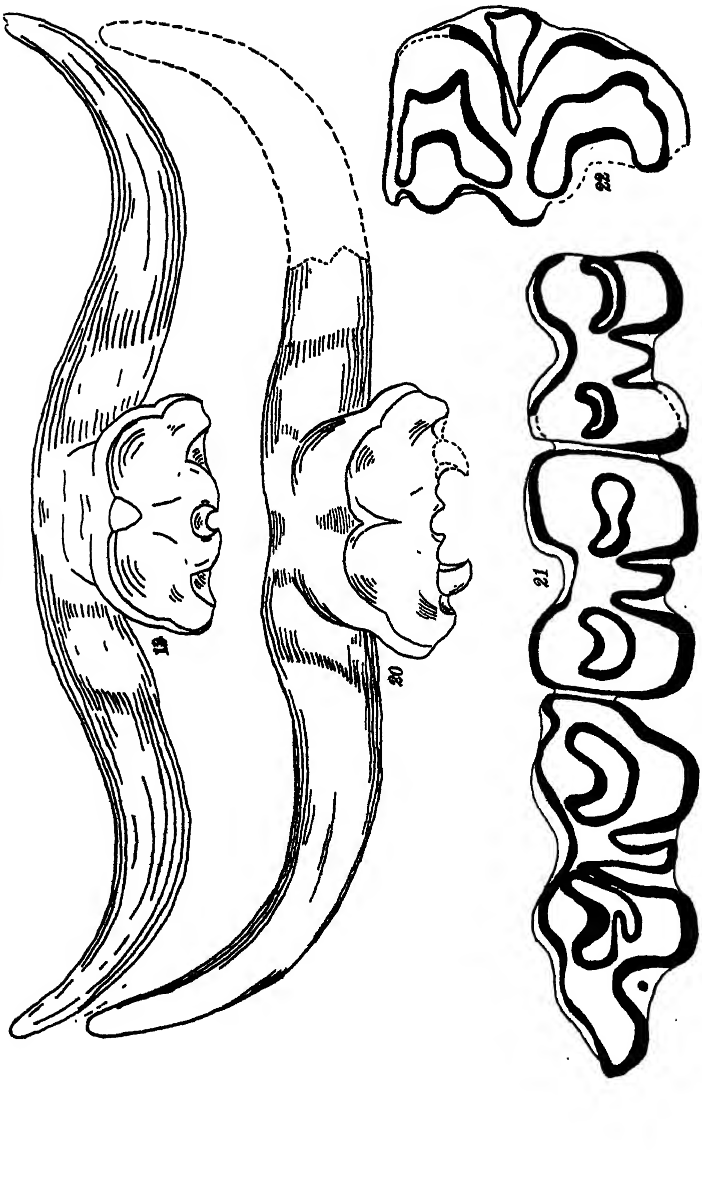
FIG. 19. *Bison* sp., posterior view of skull of K.U.M.V.P., No. 4927, × approx. ⅛.

FIG. 20. *Bison* sp., posterior view of skull of K.U.M.V.P., No. 4634, × approx. ⅙.

FIG. 21. *Bison* sp., right M_1-M_3 of K.U.M.V.P., No. 4634, × 1.

FIG. 22. *Bison* sp., left upper molar of K.U.M.V.P., No. 4634, × 1.

PLATE V



The Collateral Circulation in the Hind Limb of the Cat

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It is well known that nature has provided an emergency blood supply in nearly all parts of the body, through the collateral circulations. One of the notable contributions in this field is that of Apgar[1]. He ligated the abdominal aorta of the cat below the renal arteries. His cats showed paralysis of the hind limbs immediately following the operation, but most of them recovered within 24 hours. It seemed that further experimental study of this problem might be valuable, by using a vessel of less importance than the aorta. Because of its size and position near the skin, the femoral artery was selected. It is hoped that this study will contribute to our understanding of the effects produced by the artificial closure of a large vessel, thus making the region dependent upon the collateral vessels for its blood supply.

In this study twelve adult cats (three males and nine females) were used. All of the cats were apparently in good health. The cats were anesthetized with ether, and then the hair on the inner side of the left thigh was denuded with sodium sulfide. The field was sterilized with alcohol. The femoral vessels and nerve were located and the femoral artery was dissected free and ligated in two places about half a centimeter apart and distal to the origin of the profunda femoris artery. The instruments were sterilized by boiling, and the hands of the operator were washed and then sterilized with alcohol. Sterile surgical silk was used for ligating the artery. The skin wound was closed with silk, and without further dressings the animal was returned to a clean cage. In none of the twelve cats was there any infection other than a slight accumulation of pus under the skin in one case. In a few days the incisions were healing satisfactorily.

Each of the cats was watched while recovering from the anesthetic, and in every case movements were equally good in both hind limbs. In one or two cats the left, or operated leg was moved first. This may have been a reflex caused by the irritation due to the removal of the hair, and the operation. In none of the cats was there any evidence of even a temporary paralysis of the operated hind limb. After they had fully recovered from the ether several of the more docile cats were removed from their cages and allowed to run around the animal room, climb up on cages and chairs, and no difference in the use of the two hind limbs could be seen.

One cat was killed on the third day after operation; the others were kept from five to twelve days, and then killed with chloroform. Embalming solution was injected into the abdominal aorta below the renal arteries, thus filling the vessels of both hind limbs. As the injection mass was forced into the vessels, the muscles which were still alive would twitch, and the muscles of the unoperated limb would show the effects of the solution first and a little later the muscles of the operated leg would show the same response, showing that it took a little longer for the embalming solution to reach the thigh muscles in the

Trans. Kansas Acad. Science, Vol. 42, 1939.

1. Apgar, C. S. The arterial collateral response in the cat following ligation of the abdominal aorta. Anat. Rec., 49:133-148. 1931.

limb in which the femoral artery had been cut. No record of this time interval was kept, but it was not more than a few seconds. In each cat the effectiveness of the ligation was tested, and in every case it was impossible to force embalming fluid past the double ligation. In some of the cats the femoral artery was cut between the two ligatures at the time of operation, but in every cat the closure of the artery was complete.

The hind limbs and the lower part of the trunk were preserved in ten percent formalin, and later the vessels were dissected out. It was not possible to get satisfactory measurements of the diameters of the vessels in the operated and in the unoperated thighs, but an increase in size in the obturator and gluteal vessels seemed evident on the operated side. In no case was it possible to actually follow the course of the blood through the anastomoses back into the femoral artery, although this must have occurred in the maintenance of normal function in the operated extremity.

The number of specimens is insufficient for any but tentative conclusions, and yet the uniformity of the response should give some weight to these results. It would appear that the occlusion of the femoral artery distal to the origin of the profunda artery does not impair the functioning of the hind limb of the cat, even temporarily. It does reduce the rate of flow of blood to the limb, however, as shown by the slightly delayed muscular response to the injection fluid, even after the extremity has had time to adjust itself to the new blood supply. This would suggest that the normal circulation to the extremity is more than ample.

Injection of Corpora Lutea Extract in Pregnant Guinea Pigs on a Vitamin C-Limited Diet [1]

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Abortion or resorption of the embryos occurs in pregnant guinea pigs kept on a diet limited in vitamin C, but otherwise adequate. No pregnancy was obtained on less than 3 ml. of orange juice per day for each 300 gm. body weight, according to Kramer, Harman and Brill ('33). In pregnant animals that received this amount or less, resorption of the embryos took place in all cases. Saffry, Kramer and Harman ('37) reported that characteristic structural changes which took place in the endometrium accompanying vitamin C deficiency are associated with the resulting abortion and resorption. The average duration of gestation in pregnant guinea pigs fed a diet limited in vitamin C equivalent to 3 ml. orange juice per 300 gm. body weight was found to be about twenty-eight days.

Leo Loeb ('08) showed that corpora lutea were necessary for the formation of deciduomata in guinea pigs whose uteri had been stimulated by an incision. He could produce deciduomata only in those animals with intact ovaries and then only from the fifth to the ninth day after oestrus, the period in which the corpus luteum is functional.

Goldstein and Tatelbaum ('29) used injections of 0.5 ml. corpora lutea extract to produce placentomata by uterine stimulation in ovariectomized guinea pigs, while Allen and Corner ('30) used from 0.2 to 0.5 ml. to maintain pregnancy in rabbits after very early castration. Herrick ('28) found that if the ovaries of a pregnant guinea pig were removed, abortion occurred in most instances, but it was possible for pregnancy to continue if the ovaries were removed after the middle of the gestation period. He found that implantation of foreign ovaries in ovariectomized animals usually prevented abortion.

MATERIALS AND METHODS

The following experiments were conducted to determine if the abortion and resorption observed during the gestation period of the guinea pigs on the limited diet was due to the effect of the lack of vitamin C on the corpus luteum. By the injection of corpus luteum hormone, an attempt was made to maintain gestation in these guinea pigs in order to enable them to undergo normal spontaneous delivery.

Normal, healthy guinea pigs were used in the experiments. They were fed a standard vitamin C-free diet supplemented with greens to furnish sufficient vitamin C. Immediately after copulation the guinea pigs were placed on a diet limited in vitamin C by replacing the greens with daily feedings of standardized vitamin C tablets in amounts equivalent to 3 ml. orange juice per 300 gm. body weight.

The guinea pigs were divided into three groups. Pregnant animals com-

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1. Contribution No. 86, Department of Home Economics, and No. 208, Department of Zoölogy, Kansas State College.

prising the first group were injected with known amounts of corpus luteum hormone from the fourth day after copulation until vaginal bleeding suggested abortion or resorption.

Pregnant animals comprising the second group were fed the limited diet without injections of corpus luteum until they showed vaginal bleeding.

The third group consisted of animals which were not pregnant, but were injected with 0.2 ml. corpora lutea extract for twenty days as controls to show that the injection of corpora lutea extract does not induce a form of pseudopregnancy in nonpregnant animals.

The injections were intramuscular and consisted of corpora lutea soluble extract (each ml. of which contained 0.02 gm. extract) obtained from Parke, Davis and Company. Since Allen and Corner ('30) maintained pregnancy in ovariectomized rabbits with the use of 0.2 to 0.5 ml., trial injections of 0.2, 0.25 and 0.5 ml. were made and it was decided that 0.2 ml. injections would be adequate. When indications of vaginal bleeding were noticed, the guinea pigs were sacrificed and the contents of the uteri examined.

EXPERIMENTAL RESULTS

Group I. In guinea pigs of this group the uteri contained in every case some evidence that implantation and early development had occurred.

All the embryos found, with the exception of those in the uterus of animal S-172, were dead. Here three embryos were found, two appeared normal, but the third was partially degenerated. S-228 and S-164 were aborting, and S-168 and S-174 showed distinct areas of implantation. Twenty days after copulation S-168 had a partly open vagina and an operation was performed to examine the appearance of the uterus. An enlargement in each horn indicated the presence of placental tissue or embryos. Forty-nine days later the animal was killed and the uterus examined. There was no evidence of placental or foetal tissue or any enlargement, so it was concluded that this tissue had been entirely resorbed.

Group II. These animals were maintained under the same conditions as Group I, but were not injected with the corpora lutea extract. When open vaginas indicated the cessation of gestation, the animals were sacrificed. Placental tissue was found in each uterus examined except S-176 in which convolution of the uterus indicated that implantation probably had occurred. Three embryos, also dead, were found in S-98; and S-112 was aborting one dead embryo.

Group III. This group was used as a control group to show whether the placental and embryonic tissue found in Group I was or was not caused by the injection of the corpora lutea extract. Beginning four days after oestrus, injections of 0.2 ml. corpora lutea extract were made daily. At the end of twenty days the animals were sacrificed and examination of the uteri showed that in all animals there was no evidence of implantation or pregnancy.

DISCUSSION

The results of other workers (Herrick, '28, Allen and Corner, '30) indicate that corpora lutea extract might help to prevent abortion and continue gestation to the time of delivery. If the insufficiency of vitamin C affects the corpus luteum causing abortion, the injection of corpora lutea extract should replace the normal secretion from this structure and allow parturition, or at least

should prolong the period of foetal development. The fact that no difference in extent of development followed the injection of the extract indicated that the abortion and resorption in these guinea pigs was not due to an effect of vitamin C on the corpus luteum.

SUMMARY

1. Pregnant guinea pigs maintained on a diet limited in vitamin C aborted, or began resorption of their embryos from twenty to thirty days after copulation.

2. Injection of 0.2 ml. corpora lutea extract intramuscularly each day did not prolong the period of gestation in these animals.

3. Injection of corpora lutea extract in nonpregnant animals on a limited vitamin C diet did not induce a form of pseudopregnancy.

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TABLE I

Animal	*No. days of gestation*	*Amount of daily injection (ml.)*	*Results*
Group I:			
S 228	28	0.2	Abortion occurring; one dead embroyo, 15-20 days old
S 164[1]	20	0.25	Aborting; placental tissue
S 168[1]	20	0.5	Resorption; 2 areas of implantation
S 172	30	0.2	3 embryos, 1 dead
S 174	18	0.2	2 areas of implantation
Groups II:			
S 170	20	No injection	Placenta
S 176	30	No Injection	No placenta; uterus convoluted
S 186	25	No injection	3 dead embryos, 3 different sizes
S 98	28	No injection	3 dead embryos
S 112	25	No injection	Aborting; 1 dead embryo
	Days after Oestrus		
Group III:			
S 216[2]	18	0.2	Nonpregnant
S 226	20	0.2	Nonpregnant
S 224	20	0.2	Nonpregnant
S 222	20	0.2	Nonpregnant
S 208[2]	16	0.2	Nonpregnant

1. Injection immediately after copulation.
2. Copulation without resulting pregnancy.

The Distribution of the Genus Peromyscus in Kansas

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During the last forty years the University of Kansas Museum has collected in Kansas a large number of mice belonging to the genus Peromyscus, including several fine series of certain subspecies. At present, there are recorded three species and six subspecies of white-footed mice in Kansas, and although certain areas of the state have not had adequate collecting, it is logically assumed that some member of the genus is found in every county. Hibbard in 1933 listed in his "Check List of Kansas Mammals": *Peromyscus maniculatus bairdi, P. m. nebrascensis, P. m. osgoodi, P. leucopus noveboracensis, P. l. tornillo,* and *P. boylii attwateri.* The validity of the reference of *P. maniculatus* in southwestern Kansas to *osgoodi* is discussed later in this paper. In the summer of 1936 *P. l. aridulus* was added by Hibbard to the representatives of the genus in Kansas.

The entire Peromyscus collection of Kansas, Oklahoma, Nebraska, and Arkansas in the K. U. Museum, numbering 883 skins and skulls, has been critically examined as to color of pelage and measurements of skulls. The skulls have been carefully measured with finely adjusted dial calipers reading to tenths of a millimeter. Certain of these specimens have been checked with topotypical skins borrowed from the U. S. Biological Survey. All localities recorded on the accompanying maps (Figs. 1, 2) are represented by specimens in the Museum of Mammals, University of Kansas. Average measurements of the various series discussed are recorded in Table 1. Localities given in respect to towns or cities represent road distances, and not straight lines, from such points.

Peromyscus maniculatus Wagner

Kansas has two subspecific representatives of the species *Peromyscus maniculatus.* A discussion of the distribution of each of these forms follows and their known distribution in the state is shown in figure 1.

Peromyscus maniculatus nebrascensis Mearns

Type locality. Deer creek, western Nebraska.

This subspecies is found throughout Kansas west of the 98th meridian; it intergrades in the eastern portion of its range with *P. m. bairdi,* between the 97th and 98th meridians.

The status of *P. maniculatus* in western Kansas has long been an undecided question. The name *P. m. nebrascensis* has been assigned to the northwest and west central form, and the *P. maniculatus* of the southwestern part of the state have frequently been referred to *P. m. osgoodi.* The practice of referring the southwestern forms to *osgoodi* does not seem justified in the light of recent collecting.

Several color trends are apparent in series of *P. maniculatus* from localities from north to south throughout the western portion of the state. *P. maniculatus* from the extreme northwest (Cheyenne and Rawlins counties) are pale,

buffy, with little overlying dusky; specimens from the west central portion (Wallace, Hamilton, Logan, Gove, Trego, and Lane counties) are brighter, ochraceous, exhibiting more dusky; specimens from the south and west (Morton, Meade, Barber and Harper counties) are darkest, of a general cinnamon-brown color, heavily overlaid with dusky.

Although a general, gradational change is evident when the series are laid side by side, many of the specimens of any one series are indistinguishable from certain specimens of any of the remaining series. The series of *P. maniculatus* from northwestern Kansas (Cheyenne and Rawlins counties) may be roughly divided into a pale group and a more dusky group; the same condition is found in the series from central Kansas (Hamilton, Logan, Gove and Trego counties), and likewise in the series from southwestern Kansas (Morton and Meade counties). The light series from Meade county is indistinguishable from the light series from Cheyenne and Rawlins counties, and is also indistinguishable from the dusky series from Logan, Gove and Trego counties. The dark group of the Meade series is likewise very similar to typical specimens of *nebrascensis* available from Sioux county, Nebraska.

The Morton county series, taken as a whole, is the darkest of any *P. maniculatus* from western Kansas, the pelage being thickly overlaid with dusky. Critical comparison of the various western Kansas series of *P. maniculatus,* with typical specimens of *P. m. osgoodi* from Carter county, Montana, fails to indicate that the name *osgoodi* should be applied to the Kansas material. The previously mentioned north-south color trend of pale to dusky (darkest in Morton county) seems to be continued into central Oklahoma, as shown by a very dark series from Dewey county, Oklahoma. Moreover, on the basis of such evidence as presented above, it does not seem advisable to refer any of the western Kansas *maniculatus* to the subspecies *osgoodi,* but rather to assign them to *nebrascensis,* at least until subsequent collecting can clarify the problem.

Localities. Barber (Aetna); Cheyenne (23 mi. N.W. St. Francis); Clark (17 mi. S. Kingsdown); Comanche (4 mi. S.W. Aetna); Gove (4 mi. W. Banner); Hamilton (1 mi. E. Coolidge, 7 mi. N.E. Coolidge); Harper (3 mi. S. Harper, 1 mi. N. Harper); Logan (10 mi. N.W. Winona); Meade (13 mi. S.W. Meade); Morton (12 mi. N.E. Elkhart); Pratt (Pratt); Rawlins (27 mi. W. Atwood, 2 mi. N.E. Ludell); Rooks (6 mi. W. Woodston); Seward (1 mi. E. Arkalon); Trego (8 mi. N. Wakeeney); Wallace (2 mi. S. Wallace).

Peromyscus maniculatus bairdi (Hoy and Kennicott)

Type locality. Bloomington, McLean county, Illinois.

Individuals of this subspecies are usually readily identified, as they retain their distinctive characters throughout most of their range, and reports regarding their distribution have not suffered the misidentifications of certain other subspecies. Valid and recognizable specimens of *bairdi* are on hand from localities as far west as Lincolnville, Marion county, or approximately to 97° W. Specimens intermediate between *P. m. bairdi* and *P. m. nebrascensis* are found in the area between the 97th and the 98th meridan, north and south throughout the width of the state.

A large series from Cloud county offers some difficulty; the majority of the specimens are close to *bairdi,* exhibiting a prominent dusky, dorsal band on

head and body. The sides of the cheeks and body are bright, tawny ochraceous, approaching *nebrascensis* in this respect, the pelage, however, being duller than *nebrascensis* of a comparable seasonal color phase from Logan county. Three adults in the series closely resemble *nebrascensis,* exhibiting a much less prominent dorsal line, the ochraceous being replaced by tawny and buff. I regard this series as intergradational between *bairdi* and *nebrascensis.*

Although it is not invariably true, it is interesting to note that while *bairdi* prefers the higher grassy prairie region, it is found in practically every type of habitat within its range. The associated *P. leucopus noveboracensis* is, however, usually limited to the moist, wooded sections.

Specimens in the K. U. Museum collection are from the following counties: Allen (Moran); Anderson (6 mi. S.W. Garnett); Chase (2 mi. W. Cottonwood Falls); Chautauqua (1½ mi. S.W. Cedarvale); Cherokee (9 mi. S.W. Columbus, 4 mi. S.E. Columbus); Clay (6 mi. S.W. Clay Center); Doniphan (Geary); Douglas (Lawrence, 2 mi. N.W. Lawrence, 7 mi. S.W. Lawrence, 1 mi. N.W. Midland); Franklin (1½ mi. S. Le Loup); Greenwood (8½ mi. S.W. Toronto); Harvey (Halstead, 6 mi. S.W. Newton); Labette (10 mi. S.W. Oswego); Leavenworth (Leavenworth); Linn (5½ mi. S.E. Fontana); Marion (1½ mi. N.E. Lincolnville, 3 mi. S.E. Lincolnville); Miami (6 mi. N. Paola); Montgomery (Independence); Osage (Carbondale); Woodson (Neosho Falls).

P. m. bairdi—nebrascensis intergrade

Clay (6 mi. S.W. Clay Center); Cloud (3 mi. E. Concordia); Cowley (Arkansas City); Ottawa (3 mi. S.W. Minneapolis).

Peromyscus leucopus Rafinesque

Peromyscus leucopus is represented by at least three subspecies in Kansas and their distribution is plotted on figure 2. The intergradation of the species along the southern border of Kansas is very puzzling, since specimens showing characters intermediate between as many as three subspecies are here to be found.

Peromyscus leucopus noveboracensis (Fischer)

Type locality. New York.

This form has a widespread distribution in Kansas, extending west to approximately the 98th meridian. *P. l. noveboracensis* intergrades west of 98° with *aridulus,* and shows a slight intergradation in southeastern Kansas with the darker *l. leucopus.* Although eastern Kansas *noveboracensis* are not typical in all respects, they retain, like the associated *P. m. bairdi,* consistent, diagnostic characters throughout much of their range, thus rendering the identification less subject to error than certain other subspecies of *leucopus.*

The relationship of several series of *P. leucopus* from southern Kansas is interesting. Specimens from the southeast corner of the state (Cherokee county) show a distinct tendency toward the darker *l. leucopus,* but are referable to *noveboracensis.* A large series of *leucopus noveboracensis* from Arkansas City are likewise rather dark. *P. leucopus* from Harper county (98th meridian) are to be regarded as intergrades between *noveboracensis* and *aridulus,* but are nearer to *aridulus.* A series from Barber county is noticeably

reddish-cinnamon and is similar to Dewey county, Oklahoma specimens, and is referable to *aridulus.*

P. l. noveboracensis is represented in the University of Kansas Museum collection from the following counties: Anderson (6 mi. S. Garnett); Bourbon (Fort Scott); Chase (9 mi. E. Lincolnville); Chautauqua (1½ mi. S.W. Cedarvale); Cherokee (3½ mi. S.W. Melrose, 4 mi. S.E. Columbus); Clay (6 mi. S.W. Clay Center); Cloud (3 mi. E. Concordia); Cowley (3 mi. S.W. Arkansas City); Dickinson (Solomon); Doniphan (Geary); Douglas (Lawrence, 7 mi. S.W. Lawrence, 1 mi. N.W. Midland); Greenwood (8 mi. S.W. Toronto, Hamilton); Labette (10 mi. S. Oswego); Linn (6 mi. S.E. Fontana); Marion (1½ mi. N.E. Lincolnville); Miami (6 mi. N. Paola, 4 mi. S.W. Fontana); Montgomery (Independence); Osage (Carbondale); Woodson (Neosho Falls).

Peromyscus leucopus aridulus Osgood

Type locality. Fort Custer, Yellowstone county, Montana.

This northern subspecies has only recently been recorded from Kansas, from the northwestern part of the state (Hibbard, 1936). Its presence, however, has been suspected for some time, since specimens rather close to *aridulus* have been taken in central Oklahoma. Consequently, one would naturally presume that *aridulus* should occur throughout Kansas, from north to south, west of the 99th meridian (excepting the southwest corner where *tornillo* occurs); such has been found to be the case. *P. l. aridulus* intergrades with *noveboracensis* to the east, with *tornillo* to the southwest, and with *texanus* to the south. Throughout much of this range, *aridulus* is found associated with *P. maniculatus nebrascensis,* but while *nebrascensis* is found in practically every habitat, *aridulus* is limited to the creek and river bottoms which traverse the country.

The identification of southwestern Kansas *leucopus* is difficult, and most of the specimens on hand show intergradational characters. Specimens from Morton county are referable to *tornillo,* and appear to be typical in most respects; a series from Clark county is close to *aridulus,* but shows slight intergradation with *tornillo;* series from Comanche and Barber counties show intergradation between *aridulus* and *texanus,* but are referable to *aridulus;* Harper county specimens are intergrades between *aridulus* and *noveboracensis,* but are closer to the former. A series referable to *noveboracensis* is on hand from Arkansas City, approximately on the Cowley-Sumner county line.

Kansas localities are the following: Barber (Sun City, 18 mi. S. Sun City, 1 mi. S. Aetna); Clark (7 mi. S. Kingsdown); Comanche (4 mi. S.W. Aetna); Pratt; Rawlins (2 mi. N.E. Ludell).

P. l. aridulus—noveboracensis intergrade: Harper (1 mi. N. Harper)

Peromyscus leucopus tornillo (Mearns)

Type locality. Rio Grande, about 6 miles above El Paso, El Paso county, Texas.

This form comes into the picture of Kansas *Peromyscus* only in the extreme southwestern corner of the state. Typical specimens from Kansas in the K. U. Museum collection are from Morton county only, although the form probably ranges over into portions of Seward, Grant and Stanton counties.

P. l. tornillo is a subspecies limited to the arid and semiarid sections, and retains its individuality throughout most of its range. It has been confused with *texanus,* from which form it can usually be distinguished by color and cranial differences. I believe that typical *texanus* do not occur in Kansas, those forms found along the southwestern Kansas border being intergrades between *texanus, tornillo* and *aridulus.*

Localities: Morton county.

Peromyscus boylii Baird

Peromyscus boylii attwateri (Allen)

The distribution of this subspecies in the state is as yet imperfectly known. Valid specimens have been taken in Cherokee county and the form may very likely range into the adjacent counties of Crawford and Labette. However, the fact that rather complete collections in Linn, Allen, and Woodson counties have not shown the presence of *P. b. attwateri,* gives evidence that its range in Kansas is very probably limited to the Cherokee Bottoms. (Fig. 3.)

Localities: Cherokee county.

ACKNOWLEDGMENTS

The author is under obligation to Mr. C. D. Bunker, Museum of Birds and Mammals, for most helpful suggestions, and for permission to utilize the material in the K. U. Museum collection necessary for this work, and to Dr. E. H. Taylor and Dr. H. H. Lane, University of Kansas, for invaluable assistance and criticism in the preparation of this paper.

TABLE I.—Average measurements in millimeters of series of *Peromyscus maniculatus* and *Peromyscus leucopus*, from Kansas.

SPECIES.	Number of specimens.	Locality (counties).	Body length.	Tail.	Hind foot.	Ear.	Greatest length.	Basilar length.	Zygomatic breadth.	Nasals.	Bony palate.	Palatine slits.	Diastems.	Maxillary tooth row.
P. m. nebrascensis	9	Rawlins-Cheyenne	149.5	62.2	19.6	15.6	24.8	18.4	12.7	9.5	3.7	4.8	6.4	3.6
do.	8	Trego-Logan	152.0	61.5	19.8	15.0	24.7	18.5	12.6	9.6	4.0	4.6	6.3	3.5
do.	9	Meade	146.2	57.0	18.9	14.6	24.1	18.2	12.6	9.1	3.8	4.7	6.2	3.5
do.	10	Morton	143.2	56.0	18.0	14.0	24.6	18.2	12.6	9.4	3.7	4.4	6.0	3.6
P. m. bairdi	10	Douglas					23.7	18.1	12.7	9.3	3.7	4.7	6.3	3.3
do.	2	Cherokee	140.0	58.7	19.5	16.2	24.6	18.6	13.1	9.4	4.0	4.9	6.3	3.4
do.	6	Cloud					24.3	18.3	12.9	9.4	3.9	4.8	6.5	3.6
do.	6	Marion	148.0	54.3	18.0	14.0	24.9	18.9	13.1	9.6	3.9	4.7	6.6	3.6
do.	5	Harvey	154.0	60.8	19.4		24.6	18.7	13.0	9.5	3.9	4.8	6.5	3.6
P. l. noveboracensis	10	Douglas					27.5	20.8	14.2	10.4	4.5	5.1	7.3	3.9
do.	3	Cherokee	166.0	72.0	21.1	15.2	26.7	20.4	13.7	9.6	4.1	5.0	7.0	3.7
do.	8	Cloud	178.0	78.0	20.6		26.1	20.2	13.9	10.1	4.4	5.0	7.3	3.9
P. l. aridulus—noveboracensis	3	Harper					26.1	19.6	13.4	10.4	4.1	4.7	6.7	3.7
P. l. aridulus	10	Rawlins	181.9	82.3	21.9	17.0	27.2	20.9	14.2	10.7	4.6	4.9	7.3	3.8
do.	8	Comanche-Barber,	179.0	76.7	21.0	17.0	27.5	20.5	14.1	10.6	4.3	4.5	6.3	3.8
P. l. tornillo	5	Morton	168.0	75.6	20.4	15.0	26.5	19.8	13.8	10.2	4.4	4.4	6.7	3.8

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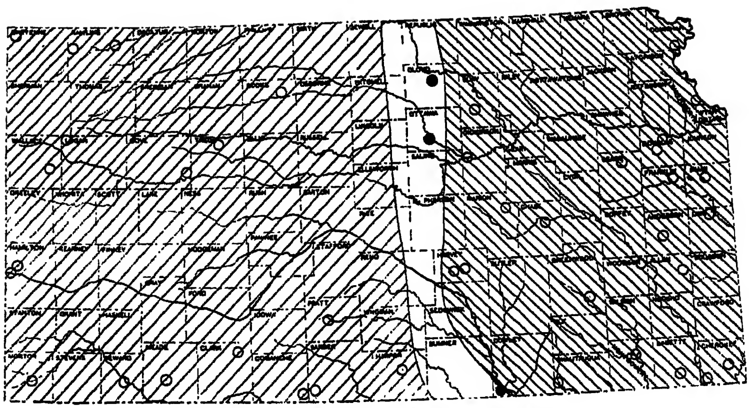

Fig. 1. Kansas Distribution of Peromyscus maniculatus.

P. m. nebrascensis — Localities

P. m. bairdi — Localities of Intergrades

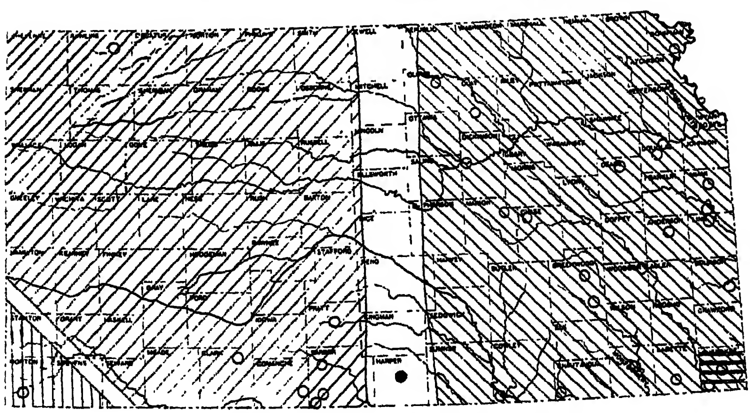

Fig. 2. Kansas Distribution of Peromyscus leucopus and Peromyscus boylii.

P. l. noveboracensis — P. b. attwateri

P. l. aridulus — Localities

P. l. tornillo — Localities of intergrades

A Preliminary Study of the Baculum of *Peromyscus leucopus* and *P. maniculatus* in Kansas

JAMES M. SPRAGUE, University of Kansas, Lawrence, Kan.

While working with specimens of *Peromyscus leucopus* and *P. maniculatus* in the Museum of Mammals, University of Kansas, I attempted to utilize the baculum (penis bone) of these forms as a taxonomic character. I had at my disposal 7 bacula of *P. leucopus* and 20 of *P. maniculatus* in my own collection, and these data, while preliminary in nature, are worth noting.

This paper deals with two species, *P. leucopus* and *P. maniculatus,* including four subspecies, *P. leucopus aridulus, P. l. noveboracensis, P. maniculatus nebrascensis* and *P. m. bairdi.* The drawings were made with the aid of a binocular microscope, and all measurements were taken with finely adjusted dial calipers. Three measurements were utilized: greatest length, measured in a straight line from the proximal end of the base to the tip of the shaft; greatest dorsoventral diameter of the base; and greatest lateral diameter of the base.

The baculum has recently been utilized in classifying North American mammals by Burt (1936) in the genera *Perognathus* and *Dipodomys,* and by Howell (1938) in the Sciurids.

Adult specimens of *P. l. aridulus* and *P. l. noveboracensis* may be readily separated from *P. m. nebrascensis* and *P. m. bairdi* on the length of the baculum alone; some subspecific differentiation is likewise possible using the same character. The individual variation of the baculum within each subspecies is marked, both as to shape of the base and curvature of the shaft.

A noticeable age variation is apparent in bacula of *Peromyscus.* Young individuals show incompletely developed bacula, characterized by shorter shafts and less bulbous bases. The bases of such bacula are incompletely ossified at their proximal ends.

A difference found to be diagnostic between these specimens of *P. leucopus* and *P. maniculatus* is one of relative size alone. It is readily seen in figure 1 that the average as well as the maximum measurements of length, breadth and thickness of bacula of *P. leucopus* are greater than of *P. maniculatus.*

The degree and relative length of the curve of the shaft vary individually in both species. The shafts of some bacula curve along their entire length, while in others the curve is limited to the distal half. The shafts of some bacula are strongly curved; others are almost straight.

The structure of the base was found to exhibit two general patterns, similar in both species. In some of the bacula it resembles a truncate spatula (Figs. 1a, 2a), while in others it is diamond-shaped (Figs. 1b, 2b). This difference does not seem to be an age variation, since both shapes are to be found in bacula of the same degree of development.

Of the two subspecies of *P. leucopus* represented, the bacula of *P. l. aridulus* are longer than those of *P. l. noveboracensis,* corresponding to the greater body

Trans. Kansas Acad. Science, Vol. 42, 1939.

length of the former. No such difference is apparent between *P. maniculatus nebrascensis* and *P. m. bairdi*.

One baculum of *P. l. noveboracensis* was found to have been broken midway in the shaft; the break had healed, leaving the distal end of the shaft projecting at a 30° angle from the long axis of the bone.

I wish to thank Mr. C. D. Bunker, of the Museum of Mammals, University of Kansas, for permission to utilize the mammal collection from which comparisons were made.

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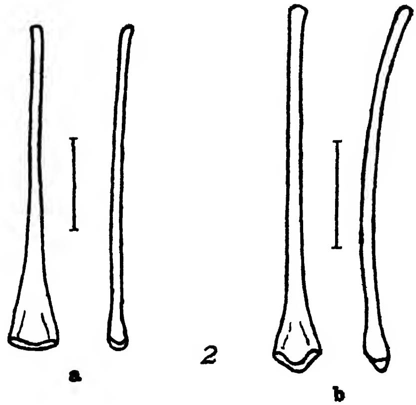
TABLE 1.—Measurement of bacula, in millimeters, of specimens of certain species of Peromyscus.

Species	*Length*	*Dorsoventral diameter*	*Lateral diameter*
P. leucopus noveboracensis	9.1	.5	1.5
P. leucopus noveboracensis	10.0	.6	1.5
P. leucopus noveboracensis	9.8	.5	1.5
P. leucopus noveboracensis	9.7	.5	1.4
P. leucopus noveboracensis	10.2	.5	1.5
P. leucopus aridulus	11.0	.8	1.5
P. leucopus aridulus	10.7	.6	1.5
Average	10.0	.57	1.5

Species	*Length*	*Dorsoventral diameter*	*Lateral diameter*
P. maniculatus nebrascensis	8.4	.4	1.4
P. maniculatus nebrascensis	7.1	.4	1.2
P. maniculatus nebrascensis	7.5	.4	1.2
P. maniculatus nebrascensis	7.5	.4	1.0
P. maniculatus nebrascensis	7.0	.3	1.0
P. maniculatus nebrascensis	7.0	.4	1.0
P. maniculatus nebrascensis	7.5	.4	1.1
P. maniculatus nebrascensis	7.2	.4	1.1
P. maniculatus nebrascensis	7.5	.5	1.2
P. maniculatus nebrascensis	7.6	.4	1.0
P. maniculatus nebrascensis	7.5	.5	1.1
P. maniculatus nebrascensis	8.2	.3	1.5
P. maniculatus nebrascensis	8.1	.4	1.1
P. maniculatus nebrascensis	8.3	.5	1.5
P. maniculatus nebrascensis	7.5	.4	1.1
P. maniculatus nebrascensis	7.7	.4	1.4
P. maniculatus nebrascensis	6.6	.4	1.0
P. maniculatus bairdi	7.5	.3	1.0
P. maniculatus bairdi	7.6	.3	1.3
P. maniculatus bairdi	6.7	.4	1.2
Average	7.9	.30	1.17



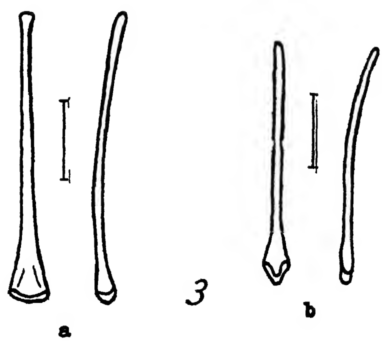


FIG. 2. Dorsal and lateral views of bacula of *Peromyscus leucopus,* showing two general patterns of the base, and the variation of the curve of the shaft. a. *P. l. noveboracensis* (9.8 × .5 × 1.6 mm.); b. *P. l. aridulus* (11 × 0.8 × 1.5 mm.).

FIG. 3. Dorsal and lateral views of bacula of *Peromyscus maniculatus,* showing two general patterns of the base, and the variation of the curve of the shaft. a. *P. m. nebrascensis* (8.4 × .4 × 1.4 mm.; b. *P. m. nebrascensis* (7.5 × 0.4 × 1.0 mm.).

The line inserted between the dorsal and lateral views designates the actual length.

Amphibians, Reptiles, and Mammals of the Meade County State Park

JOE A. TIHEN and JAMES M. SPRAGUE, University of Kansas, Lawrence, Kan.

In each of the last three summers (1936, '37, and '38) a field party from the University of Kansas Museum has spent quite a little time in the vicinity of the Meade County State Park in Meade county, Kansas. During the course of their work there, considerable information has been obtained concerning both the fossil and the recent vertebrate fauna of this area. C. W. Hibbard has recently published on the fossils, "Notes on Some Vertebrates from the Pleistocene of Kansas," Trans. Kan. Acad. Sci., 40:233-237, 1937; and "An Upper Pliocene Fauna from Meade County, Kansas," ibid., 40:239-265, but in this paper an account will be given of the recent amphibian, reptilian, and mammalian forms to be found in the park at the present time. It is hoped that in time the complete fauna of not only this park, but of all state parks in Kansas, will be thoroughly studied.

The authors wish to acknowledge their indebtedness to Mr. C. W. Hibbard and Dr. E. H. Taylor for assistance in numerous respects in the preparation of this paper, and to Mr. C. D. Bunker, Curator of Birds and Mammals at University of Kansas, for the kind permission to examine specimens and records under his care. We also wish to take this opportunity to express the most sincere gratitude of all the members of the field parties which have worked in this area, for the fine coöperation and assistance of Mr. John Carlton, the park superintendent, and by the Kansas State Fish and Game Commission.

Meade County State Park is an area of approximately twelve hundred acres, located in Meade county, Kansas, about thirteen miles southwest of Meade, the county seat, on highway K 98. The chief features and general form of the park can be seen on the accompanying map. Lake Larrabee, in the southeastern part of the park, covers an area of approximately one hundred acres. It is fed by the streams of the park area, and an outlet is provided by a spillway dam at the southeast end of the lake. Near the highway there is a bath house and sand beach, but for the most part the banks are covered with rather tall grass and herbs. In one or two spots, particularly a short distance west of the beach, there are a few trees.

The streams of the park are sandy and rather shallow. They are all fed by year-round springs which flow from the Tertiary sands. The spring near the picnic grounds flows at the rate of 280 gallons a minute, and one near the fish-breeding ponds at the rate of 180 gallons a minute. These brooder ponds are entirely spring fed, and it is from them that the stream running past them gets its chief supply of water.

The bulk of the park is typical high plains terrain, with occasional dry gulches running through it. This region belongs in the "Plains Border Section of the Great Plains Physiographic Province" of Fenneman. The geologic formations are Tertiary, consisting chiefly of sands and a few clays, but here and there are outcrops of a sand conglomerate forming rock ledges.

Trans. Kansas Acad. Science, Vol. 42, 1939.

While the biotic areas of Kansas have not as yet been well plotted, this region probably forms a part of a northward extension of the "Short-grass Plains Biotic District" of Oklahoma, as described by Blair and Hubbell (The Biotic Districts of Oklahoma, Amer. Mid. Nat., 20:425-454. 1938). The elevation is about 2,500 to 2,600 feet; the mean annual temperature at nearby Liberal is 57.1° F. (22-year record), well within the range given for points within the Oklahoma part of this biotic district. The average annual rainfall at the same station (19.02 inches, 22-year average) is, however, noticeably below the lowest record given by Blair and Hubbell for this district in Oklahoma, namely 22.39 inches at Boise City. Details concerning the flora of the park are not well known, but the principal associations given by Blair and Hubbell for this biotic district are also found here. Buffalo grass is one of the most important grasses; yucca and sagebrush are prominent in many areas; wild plum thickets are numerous on the bottom lands, and the trees to be found along the streams are chiefly cottonwoods with some willows.

For the purpose of convenience, we propose to divide the park area into three types of habitat.

Aquatic and Subaquatic

All the bodies of water in the park, and the areas immediately along their shore lines belong to this type of habitat. There are four kinds of water bodies, each with a somewhat different fauna. The lake and the brooder ponds contain the forms which prefer fairly deep water. The fauna of the streams differs from that of the lake and brooder ponds, chiefly in the almost total absence of certain forms to be found in the latter rather than in the presence of any characteristic stream-dwelling forms. In the marshy areas, which may be found near certain of the springs and in places around the edge of the lake, deep water forms are excluded and other forms enter in much greater numbers. Temporary rain ponds attract an amphibian fauna which is lacking from all other bodies of water.

Moist Lowlands

The moist lowland habitat occurs in the vicinity of the lake, the brooder ponds, and the streams of the park. It contains such plant features as trees, coarse herbs, tall grasses, and occasional plum thickets. To some extent around the ponds, and to a greater extent around the streams there is accumulated drift. This drift must be considered a salient feature of this habitat, because of the number of animals to which it affords shelter. In portions of this habitat, trees are fairly numerous; where this is true there is usually an abundance of drift and a scarcity of coarse herbs. Drift is also found in places where trees are absent but weeds are particularly coarse. Included also in this habitat are certain areas of tall grass, none of them of great extent, in which other types of vegetation are almost lacking. Certain mammalian forms are apparently to be found only in these grassy areas. The plum thickets of the lowlands offer shelter to a variety of forms, although there is no particular species which seems to concentrate here. Instead there are forms from all parts of the lowland area, excepting possibly one or two of the most typical tall grass forms, and in those thickets along the drier parts of the streams there are also a few of the high plains forms in comparatively large numbers.

High Plains

By far the greater part of the park area belongs in the high plains type of habitat, although the fauna is not quite so varied as that of the lowlands. In the typical high plains area, vegetation is sparse, consisting chiefly of short grasses and prickly pear, with here and there, patches of sunflowers along the roads or in fields which were formerly under cultivation. The dry gulches which cut this region must be considered a part of this type of habitat despite the fact that they are topographically, to a certain extent, lowlands. Along the bottom of these gulches wild plum thickets and a few hackberries are frequently found. Above these is usually considerable sagebrush, which in turn often gives way to yucca at a higher level. In places the sage extends out onto the high plains to a considerable extent. These gulches, particularly those containing rock ledges or loose rocks, contain certain forms which are not found on the high plains away from them.

Between the lowlands area and the high plains is a very poorly defined transition zone. In it we find both typical lowland forms and typical plains forms, though there is usually a noticeable decrease in the number of each here as compared with the number in their usual habitat.

In an area as small as this park it is obviously impossible to place all forms exclusively in particular types of habitat. It is, however, equally obvious that various forms tend to concentrate in certain habitats, and it is with respect to this concentration of forms that the above division has been made.

There follows an annotated list of the amphibians, reptiles, and mammals which have been taken or observed within the park or in areas directly adjacent to it.

AMPHIBIANS

Scaphiopus bombifrons Cope. The spadefoot toad, although it occurs in this area in great numbers, is seldom seen. In dry periods it buries itself some distance under the surface of the ground and comes out, for the most part, only after rains. Except during breeding season, the normal type of habitat is that of the high plains; several of them have been dug out of the banks of the dry gulches of that habitat. During breeding season, however, they may be found in great numbers around the temporary upland rain ponds. In fact, the numbers of this form congregating around these places probably exceeds that of any other amphibian, with the possible exception of *Bufo cognatus*. On the night of June 17, 1938, after a heavy rainfall, many of them were observed calling from a large rain pond and two nearby smaller ones about a mile and a half east of the lake, and from this point an exceptionally large chorus could be heard some distance to the south. Upon investigation we found the source to be a large rain pond over two miles from the point at which we were when the chorus was first heard. The frogs in this pond appeared to be exclusively *Scaphiopus*, and we estimated that there were at least five hundred of them there. A number of these were calling from beneath the surface of the water. Several trips were made during the next two weeks to the ponds first mentioned for the purpose of collecting larvae, and it was interesting to note that the larvae in the two smaller ponds, which were drying up the fastest, showed a greater rate of development than those in the more permanent large pond. This was true not only of the *Scaphiopus* larvae, but, also, to a possibly even

greater extent, of those of *Bufo cognatus,* and to a certain extent with those of *Bufo woodhousii* and *Rana pipiens.*

Bufo cognatus Say. This toad is essentially a lowland form, but it is by no means uncommon in the high plains. During breeding seasons it is to be found in profusion around the temporary rain ponds, very often in association with *Scaphiopus.* It is somewhat secretive during dry times, but not nearly to the extent of the spadefoot, for it is often to be found feeding on insects in the evening.

Bufo woodhousii woodhousii Girard. This large toad is confined somewhat more to the lowlands than *B. cognatus.* It is to be found in the evenings about as commonly as *cognatus,* but has never been found breeding in such great numbers. This may be due to the fact that we have done no collecting here in the early spring, but since this is not ordinarily a particularly early breeding form, it seems more likely that it is actually less numerous than the preceding forms, but not so secretive during dry periods.

Acris gryllus (Le Conte). The little cricket frog is common throughout the subaquatic areas of the park. It has never been observed in any temporary rain ponds here, though there is the possibility that it utilizes them for breeding places to some extent in the earlier spring. The most important breeding places, however, are more likely the certain permanent, rather marshy areas around the lake and the brooder ponds and above the picnic ground springs, for it is in these places that they are most frequently heard calling later in the year.

Rana catesbeiana Shaw. The bullfrog is confined exclusively to the subaquatic regions around the lake and the brooder ponds. While it is not rare, it is by no means as common as any of the amphibians previously mentioned.

Rana pipiens Schreber. The spotted frog is very abundant around the shores of the brooder ponds, is found to a lesser extent around the lake, and is not infrequent along the deeper parts of the streams. It has also been observed in connection with the temporary rain ponds, but not in large numbers. The chief breeding season for this frog here is probably in the middle to latter part of April, for in those portions of July the banks of the brooder ponds become literally alive with hundreds of newly metamorphosed frogs of this species. This frog is not confined to the subaquatic habitat as is the bullfrog, for many can be found in the coarse herbs and grasses of the lowlands a considerable distance from the water.

Microhyla olivacea (Hallowell). The narrow-mouthed frog is apparently rare in this area, for despite the fact that it seems to be a rather late breeder, we have heard only two specimens calling here. These were not heard in the park itself, but in the large rain pond east of the lake, previously mentioned in connection with *Scaphiopus,* and on the same date. We made attempts to secure both specimens, but could get only one, and this one only after about two hours of searching. It called only infrequently, and seemingly from a different spot each time; but it remained in the vicinity of a patch of sunflowers in nine to eighteen inches of water, using the leaves of these plants for concealment.

LIZARDS

Crotaphytus collaris collaris (Say). The collared lizard is very common in the dry gulches of the high plains region and is apparently confined to them. It is to be found chiefly in those gulches where rock ledges or loose rocks occur, but it is not rare in others free of rock, where it takes shelter in holes in the bank.

Holbrookia maculata maculata (Girard). The little sand lizard is a very common one in this area, being exceeded in number only by *Cnemidophorus sexlineatus*. It is chiefly a high plains form, but it is very common in the transition zone and extends down into the lowland area to some extent. Some of these little lizards exhibit the most amazing curiosity; it was a frequent occurrence for them to appear while we were working in the quarry and watch us for hours at a time. In the summer of 1936, for over a week, one in particular was an almost daily visitor. He would arrive in the morning soon after we put in our appearance and take up a position near us, placing his front feet on a clod so as to be sure not to miss anything. In the hotter part of the day he would seek out the shade of a particularly large clod, but would never leave us for any length of time.

Sceloporus consobrinus consobrinus (Baird and Girard). This lizard is found only in the moist lowland habitat in this area. It is most frequently found in the regions of heavy weeds, particularly in places where drift has accumulated among the weeds. It is also comparatively common in the territory immediately around the picnic grounds spring and the spring house. It is found occasionally in the drift of the wooded portions of the lowlands.

Phrynosoma cornutum (Harlan). The horned toad is almost as common in the high plains habitat as *Holbrookia,* but does not extend into the lowlands as the latter does, and comes into the transition zone in somewhat lesser numbers.

Cnemidophorus sexlineatus (Linné). The six-lined lizard easily outnumbers any other in the park area, due to the fact that it will live almost as readily in one type of habitat as another. It occurs somewhat more frequently in the slightly sandy areas of the high plains than any other place, and yet at the same time is much more common than *Sceloporus* in the moist lowlands.

SNAKES

Leptotyphlops myopica (Garman). The only specimen of this rare burrowing snake from this area is one which was found on June 18, 1936, by Mr. Kline, who was a foreman in the CCC camp there at the time. It was collected from a rocky hillside during the quarrying of rock, but due to the lack of a sufficient number of specimens we cannot say to what extent it occurs in this habitat as compared with the other types of habitat.

Heterodon nasicus (Baird and Girard). The hog-nosed snake is rather common in this area. It is fairly well confined to the high plains, but comes well down into the transition zone and infrequently even into the lowlands.

Coluber constrictor flaviventris (Say). The blue racer is one of the most common snakes of the park area, and is found in the high plains, through the transition zone, and into the moist lowlands. Unlike any of the previously named forms, it seems to have its greatest concentration of numbers within

the transition zone. It is, however, somewhat more of a plains type than a lowland type, and is to be found a little more commonly in those areas within the transition zone which tend slightly more towards the plains habitat than in those which tend more towards the lowlands type of habitat.

Masticophis flagellum flavigularis (Hallowell). The whip-snake seems to occupy a habitat very similar to that of the blue racer, but is by no means as numerous.

Arizona elegans elegans (Kennicott). This is another form of which only one specimen has been taken. This specimen was dug from a small cavity extending back for about a yard into the bank of a dry gulch running through the deer park on July 1, 1937.

Pituophis sayi sayi (Schlegel). The bullsnake is very common throughout the park area, and is to be found in almost any type of habitat, possibly slightly favoring the high plains. It is, of course, excluded from the purely aquatic habitat, but has been found immediately along the banks of streams.

Lampropeltis calligaster (Harlan). Only one specimen of the common king-snake has ever been found in this area, so it is impossible to say definitely just what type of habitat it prefers. The one taken, however, was picked up crossing the highway in the high plains west of the beach on July 17, 1937.

Lampropeltis getulus holbrooki (Stejneger). The "salt and pepper" king-snake is represented by two specimens. One was found in the afternoon of July 20, 1937, near a rock pile by the edge of the beach, and the other one was taken on August 6, 1937, near the spillway at the south end of the lake. This would indicate a preference for the lowland type of habitat.

Rhinocheilus lecontei Baird and Girard. This snake has not yet been taken within the park area, but has been found only a few miles east of it, in Meade county.

Natrix erythrogaster transversa (Hallowell). The yellow-bellied water snake is fairly common in the subaquatic regions of the park area, particularly around the brooder ponds and the lake. It is not confined to the subaquatic areas, however, for it frequently ventures out into the lowland areas near the water where there is sufficient protection, such as particularly coarse herbs or grasses or piles of drift.

Natrix sipedon sipedon (Linné). The red-bellied water snake is much less common than the preceding form. It is found in practically the same type of habitat, but is more prone to stay close to the edge of the water. This form and the preceding one are both very deleterious to the young fish, and the park superintendent makes every effort to keep their number down, particularly around the brooder ponds.

Thamnophis marcianus (Baird and Girard). Marcy's garter snake has been taken in Meade county, but not as yet within the park area, though it almost certainly occurs here.

Thamnophis radix (Baird and Girard). The plains garter snake is one of the commonest snakes in the park. It is very abundant in the subaquatic areas and the regions of moist lowlands near the water, but is not confined to them. It is not as a rule commonly seen on the high plains, but it will be found around the edges of almost any temporary rain pond in which a large number of frogs and toads are congregated, no matter how far this pond may be from any permanent water.

Thamnophis sauritus proximus (Say). This form is not nearly so common as *T. radix,* and seems to be confined to regions very near permanent bodies of water.

Thamnophis sirtalis parietalis (Say). The red-barred garter snake is not common in the park. Due to the lack of very many specimens, we cannot say definitely what its habitat preferences here are, but it appears to stay rather close to permanent bodies of water.

According to the reports of Mr. Carlton and other inhabitants of this region, a number of rattlesnakes have been killed in this vicinity, but we have not as yet been able to procure any specimens. From the descriptions given us, it would appear that two species of rattlesnakes occur here, most probably *Crotalus viridis viridis* (Rafinesque) and *Sistrurus catenatus tergeminus* (Say).

TURTLES

Kinosternon flavescens (Agassiz). The so-called "stink-pot" is very common in all the waters of the park area.

Chelydra serpentina (Linné). The snapper is common in the deeper waters of the park, that is, the lake and the brooder ponds, and is to be found occasionally in the shallow streams. Due to its size and speed, it is one of the most important enemies of the fish here.

Terrapene ornata (Agassiz). The common terrapin is abundant throughout the high plains regions of the park, and is only slightly less numerous in the lowlands. It is probably the most commonly seen reptile here, with the possible exception of *Cnemidophorus.*

Chrysemys picta bellii (Gray). This turtle is very common in the lake and in the brooder ponds. It also is an important enemy of the fish, and certainly a great nuisance to fishermen.

Pseudemys troostii (Holbrook). This form is found in the same type of habitat as the above, but it appears to be somewhat less numerous, as judged from the number killed by Mr. Carlton in attempts to protect the young fish in the brooder ponds.

Platypeltis spinifera (Le Sueur). The soft-shelled turtle is found chiefly in the deeper waters of the park, coming infrequently into the streams. It has not been observed as commonly as the other forms, but this may be due partially to its greater ability to remain out of the way of enemies. The generic name *Platypeltis* must be used in place of *Amyda* for the American soft-shelled turtles, as shown by Dr. H. M. Smith in his "Notes on Mexican Reptiles and Amphibians," Zoöl. Ser. Field Mus. Nat. Hist., 24:15-35. 1939.

MAMMALS

Since the Meade County Park is a state game refuge the specimens of species taken in traps were obtained outside of the park boundaries. The habitat groups, referred to previously, are not limited to the park area, but are continuous into the surrounding country, and the mammals known only from specimens taken just outside of the park, are logically assumed to range also within its boundaries.

Didelphis virginiana virginiana Kerr; Virginia opossum. The opossum is a common inhabitant of the lowland area, occasionally invading the transitional or even the high plains areas. The range of the opossum is limited chiefly to

the belt of trees or to a protective cover of undergrowth found near the water-courses.

Scalopus aquaticus intermedius (Elliot); Southern plains mole. Moles are common in the woodlands and meadows of the lowlands near the brooder ponds and Lake Larabee. During wet weather they range up into the transitional, only to retreat when the soil of the latter region becomes too hard, and food becomes scarce.

Cryptotis parva (Say); Little short-tailed shrew. This shrew, the smallest mammal found in the park area, is known only from skulls obtained from owl pellets, picked up near the east end of Lake Larabee. The short-tailed shrew is a rare inhabitant of the tree belt of the lowland area.

Bats. At least two unidentified species of bats were observed flying over the brooder ponds in the late evening.

Procyon lotor hirtus Nelson and Goldman. The racoon is a common inhabitant of the lowland area, its tracks being a frequent find along the water-courses near the brooder ponds.

Mephitis mesomelas varians (Gray); Long-tailed skunk. Skunks were common throughout the lowland and transitional areas. One family was observed to be denning under a deserted cabin located within the latter area. Skunks were frequently observed at dusk feeding on grasshoppers in the lowland meadows adjacent to the brooder ponds. Many half-grown skunks were observed during the month of July, and a lactating female was taken on July 28.

Vulpes velox velox (Say); Swift fox. The only records of this rare fox are two. One animal was flushed by Mr. C. W. Hibbard just south of the park area. Another swift fox was killed on Big Springs Ranch, north of the park, and although the specimen was not seen by the authors, the source of information is reliable. This handsome fox is limited to the high plains area, and unfortunately, is near extinction in the state.

Canis nebrascensis subsp? The familiar prairie coyote is common throughout the high plains and transitional areas of the park.

Felis domestica Linné. Domestic cats, abandoned by picnickers or run feral from ranchers' homes, are numerous, and constitute a menace to wild game birds and poultry alike. Many cats were living under deserted cabins of the CCC camp near the picnic grounds, and signs of their depredations on song birds and quail were frequent. This vicious little feline should be brought under some practical control, and it is suggested that the practice of humanely killing unwanted cats is far better conservation than is that of turning them out to prey on the already diminished wild game birds.

Citellus spilosoma major (Merriam); Large spotted ground squirrel. This mammal, ranging into Kansas from the southwest, is a rare inhabitant of the high plains. Two individuals have been observed close to the park boundary.

Citellus tridecemlineatus arenicola Howell; Sandhill striped ground squirrel. This animal was seldom seen and apparently is not a common mammal of the park. Its burrows are limited to the high plains.

Cynomys ludovicianus ludovicianus (Ord); Black-tailed prairie dog. The only protected colony of prairie dogs in Kansas is found in Meade County State Park west of Lake Larabee. While certain charges against the destructive activities of this rodent are justified, the animal certainly should not be slated for speedy extinction in the state. The prairie dog forms a very colorful

and interesting part of our native wild life, and should be protected and preserved in certain state and county game refuges. *Cynomys* is a form living in colonies and towns scattered over the high plains area. The animal, once everywhere abundant, has now become rare or extinct over many portions of the state, due to thorough and oftentimes needless shooting and poisoning. With the protection of a few towns in areas not otherwise utilized, *Cynomys* may remain a permanent member of our native fauna.

Sciurus niger rufiventer (Geoffroy); Western fox squirrel. This squirrel is a common inhabitant along the wooded streams of the lowland area.

Geomys breviceps llanensis Bailey; Mesquite plains pocket gopher. Gopher colonies are numerous in the lowland and transitional areas, but chiefly in the lowland meadows where the softer, richer soil makes a more desirable habitat.

Perognathus flavus flavus Baird; Baird pocket mouse. Only one specimen was taken of this little mouse, and that just outside of the park area. Although such evidence cannot be taken as an absolute criterion of its abundance, it cannot be considered common. It is limited to the high plains, its burrows being found along the shallow sand washes of the latter region.

Perognathus hispidus paradoxus (Merriam); Kansas pocket mouse. Growths of weeds or high grasses on the high plains furnish cover for this sparsely distributed pocket mouse.

Dipodomys ordii richardsoni (Allen); Richardson kangaroo rat. The kangaroo rat is an inhabitant of the gulches and sand washes of the high plains, in which localities it is one of the most common mammals. Here it is found associated with *Neotoma m. micropus, Perognathus f. flavus, Onychomys leucogaster articeps* and *Sylvilagus audubonii neomexicanus*. The kangaroo rat is a wide ranger; the tracks of a single individual may be traced for a quarter of a mile along a sandy stream bed. The burrows are frequently changed, an individual usually remaining in one burrow for only a few days, then deserting it and digging a new one. Those burrows in use are tightly plugged with sand during the day, and are surrounded by a maze of footprints and marks made by the long tail which it frequently drags along the ground. The kangaroo rats proved difficult to trap, neither oats nor oats-bacon-raisin bait proving especially attractive to them.

Onychomys leucogaster articeps (Rhoads); Great plains grasshopper mouse. This mouse is limited to the high plains area, over which it is very common. The grasshopper mouse is a wide-ranging form, and traps set with dry oats or, preferably, an oats-bacon-raisin bait would catch them in even the most exposed stations. Two color phases of brown and slate-gray were found, the latter being much more common. The grasshopper mouse in Kansas has at least two litters a season, for females bearing full term fetuses were taken June 18 and 30, and July 20, while a female bearing fetuses approximately one-fifth grown was taken July 16. Four to five young is the common number.

Reithrodontomys albescens albescens Cary; Pallid harvest mouse. An owl roost located in a ravine in the high plains yielded the only remains of this harvest mouse. Its range seems to be limited to such ravines, in which the herbs, grass and undergrowth are abundant, and judging from the skulls found beneath the roost, it is not uncommon in these localities.

Peromyscus maniculatus nebrascensis (Coues); Nebraska deer mouse. This mouse is one of the most common mammals in the park area. Although it is

limited chiefly to the high plains and the transitional areas, I have taken specimens of *nebrascensis* in *Sigmodon* sets placed in the tall grass of the upper border of the lowland region. Over much of the high plains, *P. m. nebrascensis* ranges coincident with *Onychomys leucogaster articeps,* and *Perognathus hispidus paradoxus;* with *Reithrodontomys albescens albescens* in the high ravines; and with *Perognathus flavus flavus* and *Dipodomys ordii richardsoni* along the dry sand washes of the high plains area. *Peromyscus maniculatus nebrascensis* begins its foraging soon after dark, for specimens are not infrequently seen by lantern-light between 9 and 10 p.m. Dry oats, oatmeal paste, and oats-bacon-raisin baits were all successful in trapping for *Peromyscus.* A female carrying fetuses one-fifth full term was taken June 19.

Sigmodon hispidus texianus (Aud. & Bach.); Texas cotton rat. The cotton rat is present in small numbers in the high grass patches in the lowland and transitional areas. Sigmodon is apparently limited to these localized areas.

Neotoma micropus micropus Baird; Baird wood rat. The familiar packrat is one of the most common mammals of the park area. The rat population, however, is localized and concentrated chiefly in the rocky gulches and clay washes of the high plains. *Neotoma m. micropus* is a wide-ranging form, being found in the transitional area as well as the high plains, but is entirely lacking from the lowlands. *Neotoma m. micropus* shows a decided preference for rocky shelter rather than clay banks, where the former is available. One female carrying fetuses approximately one-fourth full term was taken June 28; a female with young one-third full term was taken June 29. Three fetuses were present in each case. Two young rats, about one-third grown were taken July 14. This would indicate that at least two litters a season were raised in this region.

Ondatra zibethica cinnamonina (Hollister); Great plains muskrat. The muskrat is an abundant inhabitant of the semiaquatic borders of the brooder ponds and Lake Larrabee. Their burrows were dug in the bank, no houses being in evidence.

Mus musculus musculus Linnaeus; House mouse. This familiar mammal is found about habitation in all types of habitat, and is frequently trapped in the long grass, weeds, or brush heaps of the lowlands and transitional areas.

Erethizon epixanthum bruneri Swenk; Nebraska yellow-haired porcupine. The porcupine is an occasional inhabitant of the wooded section of the lowland area. Porcupines are rare throughout Kansas, and unfortunately, being a curiosity to most people, this harmless and interesting animal is killed on sight.

Lepus californicus melanotis (Mearns). The great plains jack rabbit is one of the most common mammals of the park area. Its distribution is limited to the high plains, where it ranges coincident with *Sylvilagus audubonii neomexicanus.* The jack rabbit does not take to burrows as does the cottontail, but hides during the heat of the day in shallow forms dug under some yucca, sage, or cactus plant.

Sylvilagus audubonii neomexicanus Nelson; New Mexico cottontail. Two species of cottontails are found in the park area. The first, the New Mexico cottontail, is the smaller of the two, and is distributed chiefly in the rocky canyons and sand washes of the high plains, but it also ranges down into the transitional area where shelter is available. In the transitional, *neomexianus*

lives side by side with the larger, darker *Sylvilagus floridanus alacer*. In the canyons of the high plains, where *neomexicanus* is most abundant, its burrows are found adjacent to those of *Neotoma m. micropus* and *Dipodomys ordii richardsoni*. *Sylvilagus a. neomexicanus* is frequently parasitized with bots (Cuterebra), and appears to be more suseptible to the parasites than *S. f. alacer*. A lactating female, carrying three fetuses approximately one-tenth full term was taken June 18. She was apparently suckling a previous brood at the time.

Sylvilagus floridanus alacer (Bangs); The Oklahoma cottontail is limited to the windings of the more or less permanent water courses which traverse the country. It is found chiefly in the lowland area, but also ranges into the transitional, coincident with *S. audubonii neomexicanus*. A lactating female carrying four half-term fetuses was taken June 23; two other lactating females were taken June 24 and July 7.

Cerves canadensis canadensis (Erxleben); American wapiti. A pair of elk, liberated in the park enclosure, have shown an increase each year in number. The elk was once common along the lowland meadows of this region.

Odocoileus hemionus hemionus (Rafinesque); Mule deer. A number of mule deer have been introduced into the park area where they have become very tame, and have shown an increase in number each year. During the summer of 1937, while camped at the park, a young buck mule deer with two points was chased up from the Cimarron river on to the plains north of Plains, Kan. The deer was winded and stiff when found and driven into a barn, since it was thought to have been an escape from the park. Due to injuries received, it was dead by the time we reached it. The deer did not belong in the park, but was one of the few wild deer still found along the Cimarron breaks. The specimen is now in the University Museum.

Odocoileus virginianus macrourus (Rafinesque); White tailed deer. The white tailed deer has been introduced into the park area where it has become well adapted. It is also showing an increase as long as the deer remain in the protected area.

Antilocapra americana americana (Ord); American Pronghorn. Much credit is due Mr. Lee Larrabee, of Liberal, Kan., who has spent considerable time and money in trying to establish a small herd of antelope in the park. The first attempt was unsuccessful, due to shooting of one of the antelopes within the enclosure. The second pair was successful in increasing to a number of five which was reduced, however, to a single doe, due to the severe dust storms of the spring of 1937. It is hoped that the State Fish and Game Commission will purchase a mate for the remaining antelope and endeavor to reëstablish this native mammal in the park area.

Bison bison bison (Linné); Plains bison. A young pair of bison in the "Deer Park" affords the visitor a view of the once abundant mammal that roamed over our prairies. Adjoining the "Deer Park" is suitable land which would furnish an adequate range for a small herd of bison if it could be purchased by the state.

PLATE I

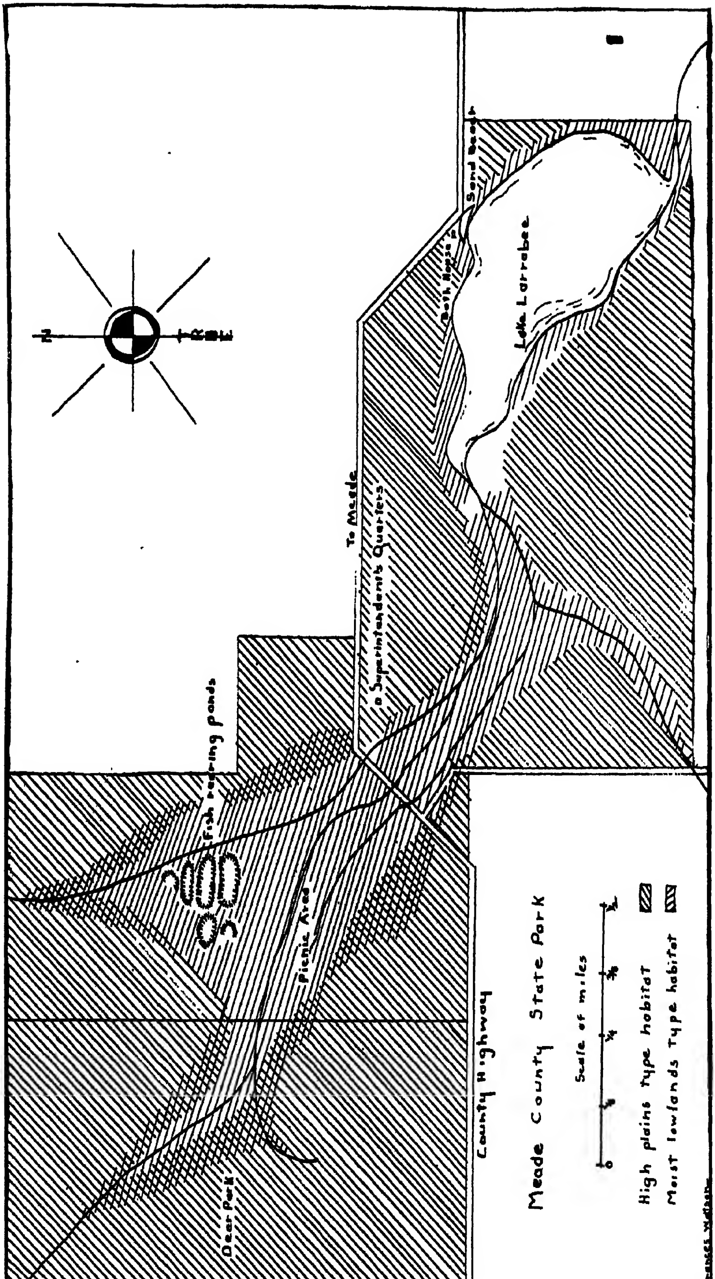
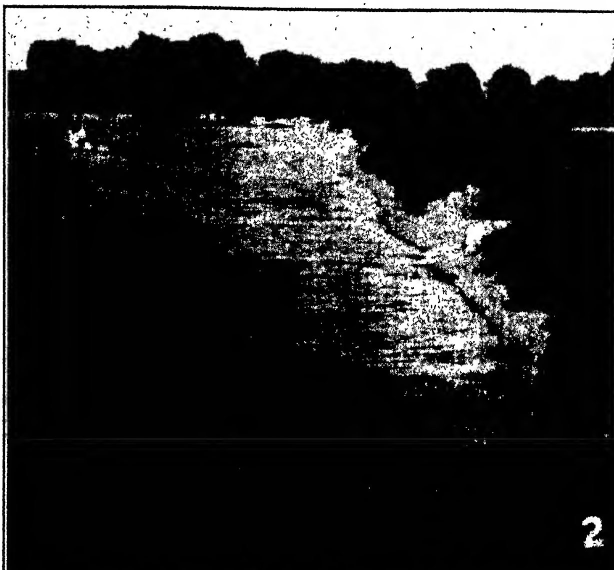


FIG. 1. Map of Meade County State Park, showing habitats

PLATE II



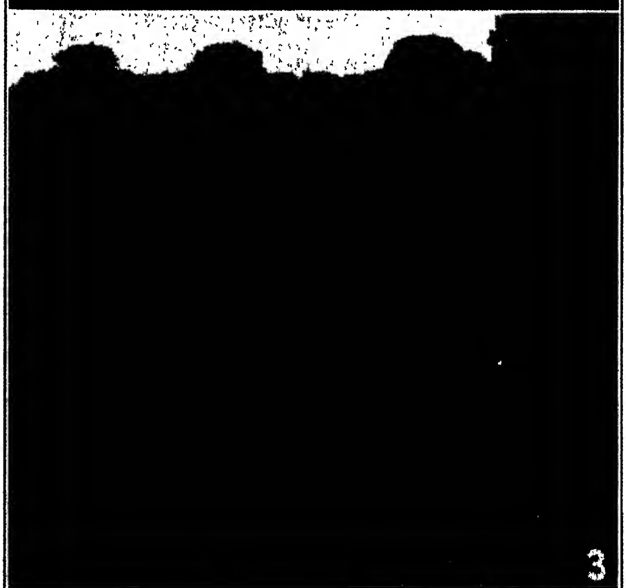


FIG. 2. Semiaquatic habitat (brooder pond), and adjacent tree belt and meadow.
FIG. 3. Lowland tree belt and meadow habitat.

PLATE III

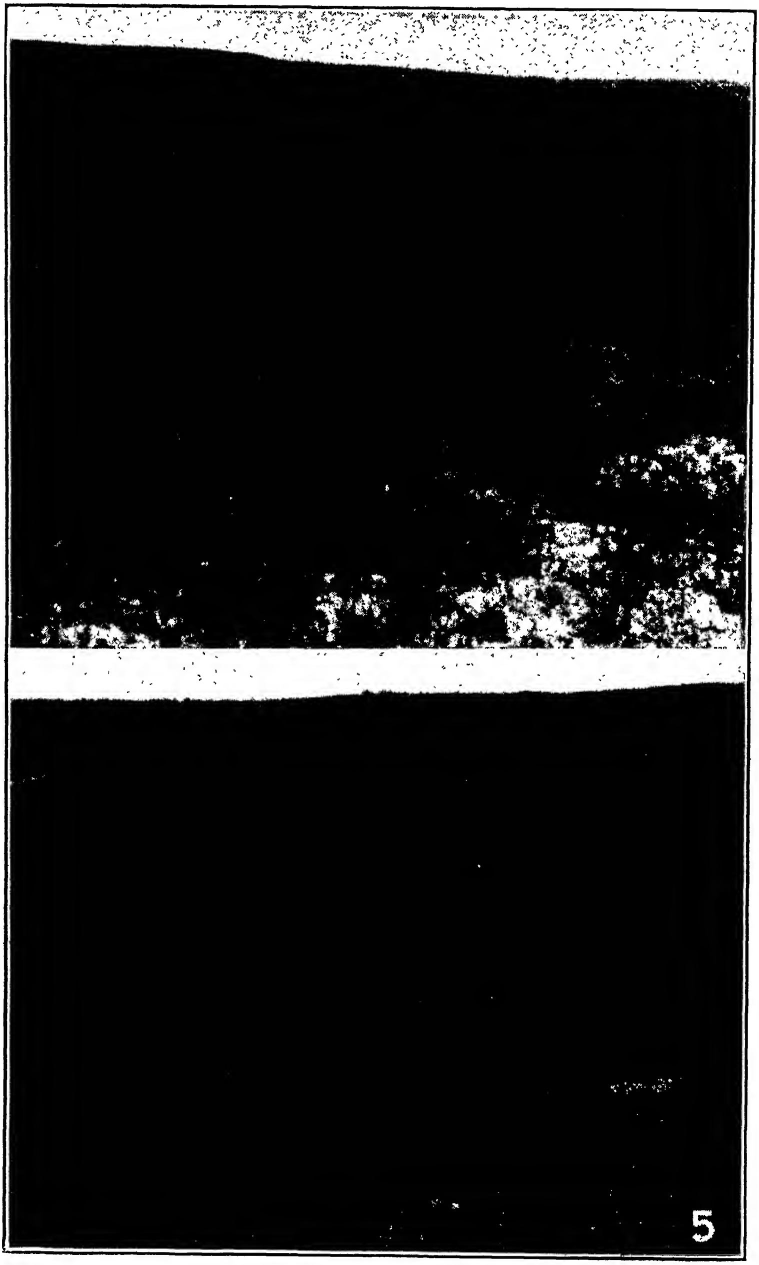


FIG. 4. High plains habitat in foreground; transitional habitat to right near trees; lowland meadow beyond trees.

FIG. 5. Rocky canyon of high plains habitat.

Tertiary Butyl Alcohol as a Dehydrating Agent in Preparing Microscopic Mounts of Insect Material

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In the past few years many substitutes for ethyl alcohol in dehydrating tissue preparatory to infiltrating with paraffin have been tested. The tendency of high percentage alcohols and xylol to harden tissue unduly has been the stimulus for these attempts.

A good dehydrating agent must be miscible in all proportions with water, ethyl alcohol (in order to permit use with fixing agents containing alcohol), paraffin and balsam, and should replace all water in the tissue without causing an alteration in its water absorbing capacity. Many of the dehydrating agents in common use and many of those which have been tried as substitutes for the common agents fail to possess one or another of these necessary properties.

Zirkle (1930) reports having used mixtures of ethyl and normal butyl alcohol in dehydrating plant tissues, and Stiles (1934) used the same procedure with animal tissue. Both investigators had very satisfactory results, and Stiles recommended the use of n-butyl alcohol in microtechnique classwork, especially with inexperienced students. Margolena (1932) used n-butyl alcohol alone in dehydrating the kidney of a guinea pig. The results were satisfactory.

Bradbury (1931) substituted isopropyl alcohol for ethyl alcohol in histologic work. Dioxan and tertiary butyl alcohol were used with excellent results by Johansen (1935). All the above-named reagents were decidedly advantageous in that they eliminated the high percentage ethyl alcohols and xylol, thus avoiding undue hardening of the tissues.

During the past few months the writer has been making a study of the chorionic sculpturing of the eggs of grasshoppers with the intention of using the patterns as a means of identifying the eggs. In order to permit photography and detailed study of the sculpturing it was necessary to mount portions of the choria on microscope slides. The usual method of dehydrating with ethyl alcohol would have been a decidedly tedious task; consequently, a new technique has been devised whereby dehydration is accomplished by means of absolute tertiary butyl alcohol.

THE TECHNIQUE EMPLOYED

The eggs were first cut longitudinally into quarters, and are then boiled in five percent sodium hydroxide to remove the egg contents and the vitelline membrane. The sodium hydroxide is decanted and the sections are washed in tap water. By means of a pipette the slide is flooded with absolute tertiary butyl alcohol and allowed to stand for ten or fifteen seconds. Then, with a piece of blotting paper, as much of the alcohol is removed from the slide as possible without endangering drying of the section. The quarter is placed in the desired position, balsam applied, and the cover slip put in place. Slides made according to this method sixteen months ago are still in perfect condition.

Trans. Kansas Acad. Science, Vol. 42, 1939.

Occasionally the chorionic sections tend to curl during the process of boiling in sodium hydroxide. It has been found that if such sections are allowed to stand for a few minutes in water to which has been added a little tertiary butyl alcohol, they will straighten out in most cases. If they fail to straighten out after having been in the weak alcoholic solution, they can usually be straightened out with dissecting needles and will remain flat. Occasionally, also, sections will curl slightly when the slide is flooded with alcohol. This, however, is not serious, and if the sections are held flat for a few seconds with dissecting needles they will retain the desired position.

Dioxane has been tried in this technique but gave very unsatisfactory results, and since most of the work has been done under a dissecting microscope, there is considerable danger from the fumes.

The technique described above can doubtless be employed in mounting quite a wide variety of insect structures, such as wings, antennae, tarsi, genitalia, etc., and modifications of it would no doubt permit even wider application. Its chief advantage is that it entirely eliminates the steps necessary in dehydrating with ethyl alcohol, thus making the process simpler and faster.

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An Ecological Evaluation of Predatees on a Mixed Prairie Area in Western Kansas

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What is the ecological value of each species of predatee, particularly from the standpoint of the predators, on an area of mixed prairie? For example, how important is the meadow mouse (Microtis) to the predators (coyotes, hawks, owls, etc.) on a given area? Is it possible to make such an evaluation? The study here reported was made in the period from 1930 to 1936, in an attempt to answer the foregoing questions.

By "predatees" is meant the mammals most commonly preyed upon by the predators. The predatee species of mammals found to be present on the area were:

Blarina brevicauda brevicauda (Say); short-tailed shrew
Cryptotis parva (Say); little short-tailed shrew
Reithrodontomys albescens griseus (Bailey); harvest mouse
Peromyscus maniculatus nebrascensis (Coues); white-footed mouse
Microtus haydeni (Baird); field mouse.
Citellus tridecemlineatus pallidus (Allen); thirteen-lined ground squirrel
Lepus californicus melanotis (Mearns); black-tailed jack rabbit
Sylvilagus floridanus mearnsi (Allen); cottontail

"Ecological value to the predators" refers to food value, which is, of course, the important item of relationship between the two "forces," predators and predatees.

By "mixed prairie" is meant that grass association lying in western Kansas north of the Arkansas river and extending up into Nebraska, in which the short grass (buffalo and grama) areas to the west and the tall grass (chiefly little bluestem) area to the east overlap, producing something of a patchwork of the two in varying proportions. The sample area of study was a square mile of typical mixed prairie located in Ellis county, Kansas, about two miles west of the city of Hays, in range 19, townships 13 and 14 south, in parts of sections 1, 6, 31, and 36.

The importance of each predatee species was figured in terms of three factors: (1) The number present on a unit area, (2) the weight of an individual of that species, and (3) the proportion of the year present and available for food. The ecological value of any given species, then, would be the average weight of individuals of that species, multiplied by the number present on a unit area, multiplied by the portion of the time of a year available for food. As a formula it would be: $N \times W \times T = V$.

Weights were obtained by weighing a considerable number of each species as captured and averaging. The results are shown in table I, column 3. Numbers of each species were obtained by two methods, transect surveys and trapping, as later described. The time present and available for food was found by observation during the process of counting, over a period of five years.

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The time that each species was present and available to predators for food was found to be a full year, except in the case of the thirteen-lined ground squirrel, which is in hibernation approximately six months of the year. It is also strictly diurnal, and because of this, it is available for food through only about three-fifths of each twenty-four hours. Therefore, it would be available only about three-tenths of the time annually.

Lagomorphs, that is, jack rabbits and cottontails, were counted once each month for twelve months by the transect survey method, as follows: Ten or more observers lined up approximately ten feet apart, and the line marched for one mile, counting all rabbits seen. From the number of rabbits counted on this sample portion of a square mile, an estimate of rabbits on a whole square mile was readily obtained. The number of black-tailed jack rabbits found to be present, on the average, on one square mile of mixed prairie, was 185. The number of cottontail rabbits found to be present on the same area was 21.

Rodents and insectivores were counted by trapping on sample quadrats of 200,000 square feet each, at all times of the year and on all kinds of habitats. It was found that the mixed prairie area was composed of five different habitats and that each species of mammal had its habitat preferences. It therefore became necessary to measure the area of each habitat as found on the square mile. From the area of each habitat and the sample trapping done on each, it was then possible to determine the total population of each species of rodent and insectivore on the whole area. The five habitats were: (1) Shortgrass, (2) dense tall grass, (3) sparse tall grass, (4) mixed shortgrass and tall grass, and (5) rock outcroppings. The trapping was done with ordinary snap mouse traps for thirty days at a time on each quadrat. It was found that an area could be trapped out in thirty days or less. It is to be noted that this is a total-trapping-out method rather than sample, one-night trappings. By the methods used it was estimated that there were the numbers of rodents and insectivores per square mile shown in table I, column 2.

Applying the formula—

number (per square mile) × weight (grams) × time=value,

we have the final ecological value for each species as follows:

TABLE I

Species.	Number per sq. mile.	Average weight in grams.	Part of year present.	Part of day available.	Total units of value.
Citellus	1,952	100.0	.5	.6	58,560
Microtus	2,462	38.0	1.0	1.0	93.556
Peromyscus	1,728	17.0	1.0	1.0	29,376
Reithrodontomys	716	9.2	1.0	1.0	6,587
Blarina	337	12.0	1.0	1.0	4,044
Cryptotis	614	4.1	1.0	1.0	2,517
Lepus	185	3039.0	1.0	1.0	562,215
Sylvilagus	21	1701.0	1.0	1.0	35,721

Thus it was found that the most important predatee in the predator-predatee relationship in this mixed prairie association was the jack rabbit; the next most important was the meadow mouse; the next was the thirteen-lined ground squirrel; and so on.

In conclusion, it has been shown that by using the three factors, numbers, weight, and time, an ecological evaluation of predatees is possible, and has been made in this study.

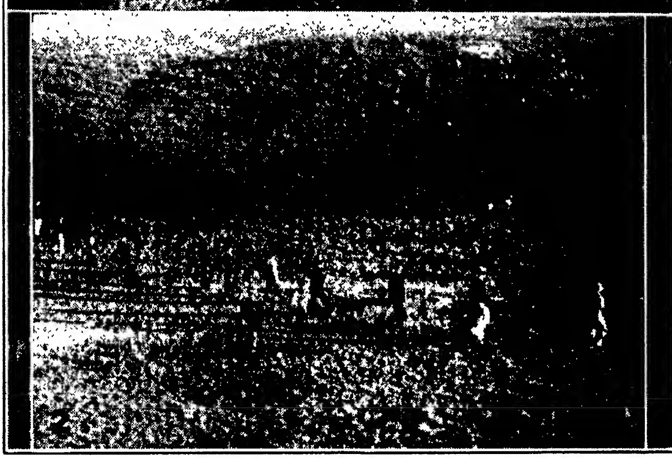

Fig. 1. A view of a portion of the area of mixed prairie studied. The light areas are short grass. The lines enclose an area of special study.

Fig. 2. The transect survey method of counting rabbits.

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